PRIMER ON FRACTURES



Prepared by the Special Exhibit Committee on Fractures in Cooperation with the Committee on Scientific Exhibit of the American Medical Association



SIXTH EDITION



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PRIMER ON FRACTURES

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SPECIAL EXHIBIT COMMITTEE ON FRACTURES

AMERICAN MEDICAL ASSOCIATION



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FOREWORD



FOURTH EDITION

In 1936 the Committee on Scientific Exhibit of the American Medical Association decided to revive the Exhibit on Fractures and to replace the Cooperative Committee on Fractures, which had been composed of Dr. Nathaniel Allison, Dr. William Darrach and Dr. Kellogg Speed, by a new committee, designated as the Special Exhibit Committee on Fractures of the American Medical Association. This new committee consists of Dr. Kellogg Speed, Chicago, Chairman, Dr. Frank D. Dickson, Kansas City, Mo., and Dr. Walter Estell Lee, Philadelphia. Two exhibits have been held under the direction of the present committee, in Kansas City, Mo., in 1936, and in Atlantic City, N. J., in 1937.

In accordance with the precedent established by the former committee in publishing a primer which contains the principles of treatment of fractures as presented in the annual exhibits of the Association, this committee has been requested to issue a fourth edition of the Primer on Fractures. A fourth edition has been made necessary by the exhaustion of the three previous editions, of which over 18,000 copies have been sold. The fourth edition attempts to bring to the Fellows of the Association and to others timely corrections and accepted advances in the principles of treatment of fractures as demonstrated by the annual exhibits held under the auspices of this committee.

A complete revision of the text and illustrations has been made. The printing of the fourth edition is made possible by the Board of Trustees of the American Medical Association through its Committee on Scientific Exhibit.

The committee wishes to acknowledge its indebtedness to the many Fellows of the American Medical Association who have made the annual demonstration possible by their contributions of time and advice.

Special Exhibit Committee on Fractures

May 1938.

CONTENTS



PRIMER ON FRACTURES



EMERGENCY FIRST AID SPLINTING FOR ARM AND LEG

Early splinting and application of fixed traction for transportation will lessen deformity, decrease shock and make complete reduction of fragments easier after fractures of the leg. The main fault of emergency treatment is that it is not applied soon enough after an accident. The injured person is picked up and transported to home or hospital without regard to the fracture. Every day many patients arrive, unsplinted, at the hospital with one or more inches of shortening and an angulated thigh or arm from overriding of

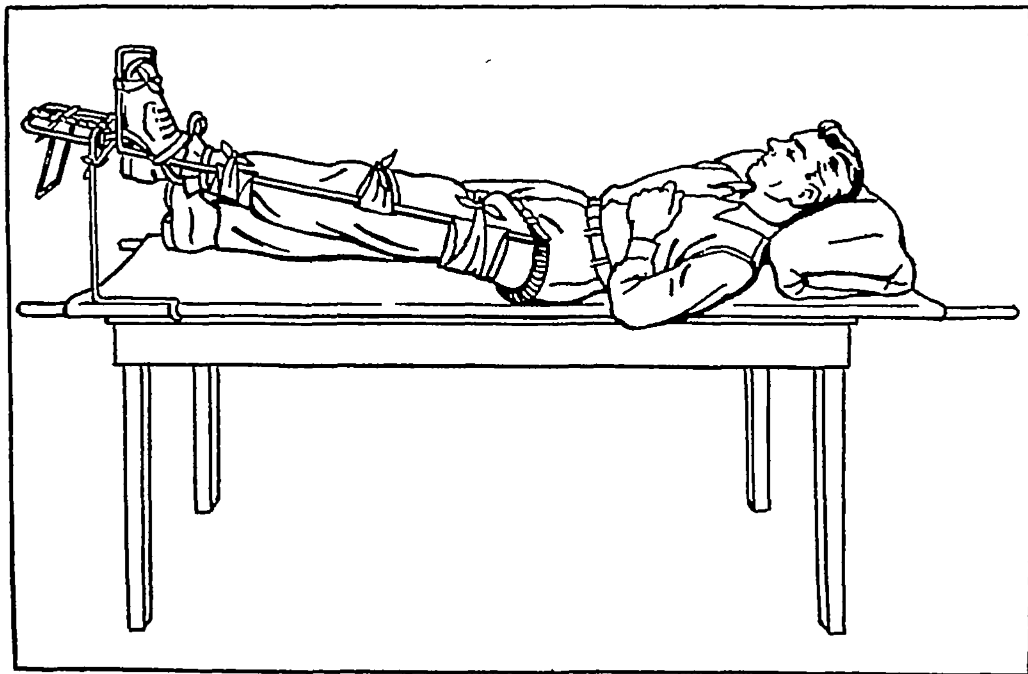


FIG 1. Emergency treatment for transportation, fracture of the shaft of the femur

fragments That these deformities and damage to tissue are unnecessary is proved by the few patients who arrive with the lower extremity immobilized in a Thomas splint An intelligent physician has applied a Thomas or suitable fixed traction splint before the patient was picked up, with the result that there is practically no pain, no overriding of fragments and less shock Ample evidence has been gained in war and in automobile or industrial injuries of the advantage of early splinting and traction for transportation.

What should be done to improve the results of emergency treatment? Insist that ambulances carry proper appliances for the

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immediate treatment by fixed traction for fractures of the leg. Application of traction splints on the arm is not considered necessary for fear of overpulling bone, blood vessels or nerves. Most arm injuries, for transportation to nearby hospital, are gently held by blanket or swathe at the patient's side or in a supporting sling pinned to the clothing without any effort at correction of displacement of bone even when obvious deformity is seen. In the absence of any open wound or bleeding, no effort is made to remove clothing

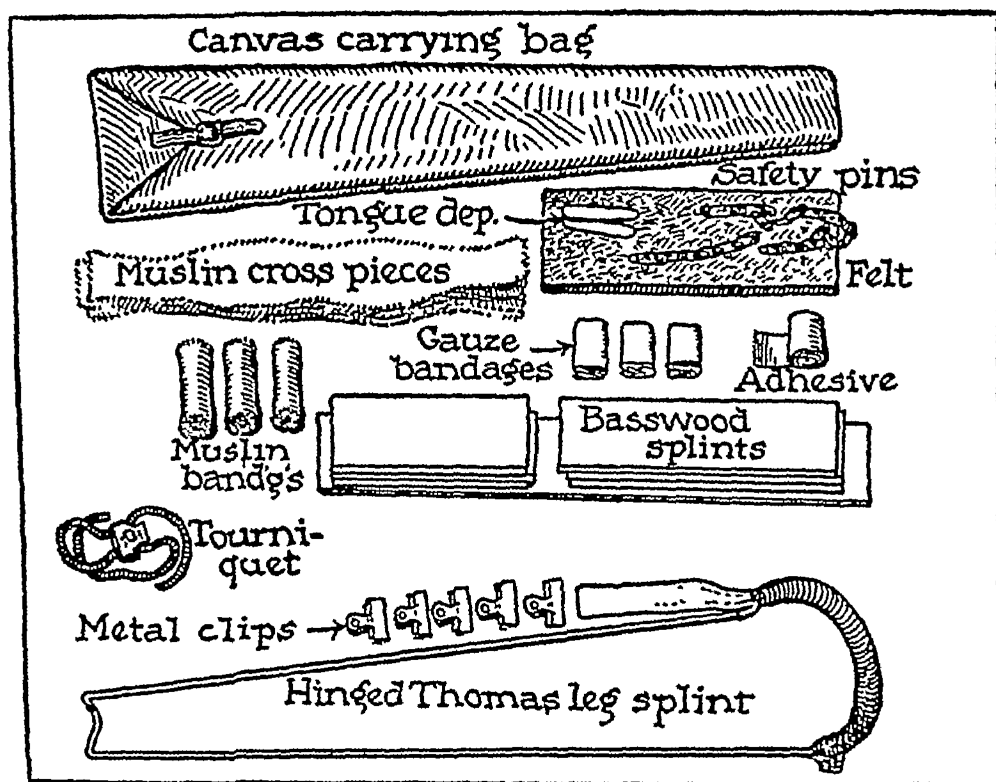


FIG. 2. Splint outfit to be carried in the physician's automobile and in ambulances.

until arrival at a place for definitive treatment. Instruct ambulance drivers in the application of splints and the necessity of blanketing the patient. Policemen and firemen should also be instructed. Physicians themselves must learn these simple tasks and should carry emergency splint equipment in their automobiles

The creed is simple: "Splint 'em where they lie." Blanket the patient and transport him safely to a proper place to undertake final revision of the fracture. If a Thomas leg splint is not available, a

NOTES

EMERGENCY TREATMENT FOR TRANSPORTATION

Blankets—splints and careful handling.

Leg fracture may be easily overlooked. Inspect and palpate. If leg is crooked, it is broken.

If there is local tenderness, assume it is broken.

Don't try for crepitus!

"Splint 'em where they lie."

Traction for transportation of leg injury; *do not remove shoe.*

A traction splint should be applied before the injured person is moved.

A properly applied traction splint will prevent overriding, further trauma and shock.

Avoid leg constriction in applying traction.

Do not manhandle leg fractures. Be gentle!

It is the doctor behind the splint and not the splint that counts in the treatment of fractures.

Immobilize knee and ankle or joints above or below fracture.

NOTES

HOW TO APPLY PLASTER OF PARIS BANDAGES

Plaster of paris dressings can be molded to fit any part of the human body. Learn to apply them to a fractured part without disturbing the corrected position of the bone fragments. After selecting the plaster bandages in the estimated size and number required, place several bandages end up in a pail containing tepid water deep enough to cover them completely. Do not handle or squeeze

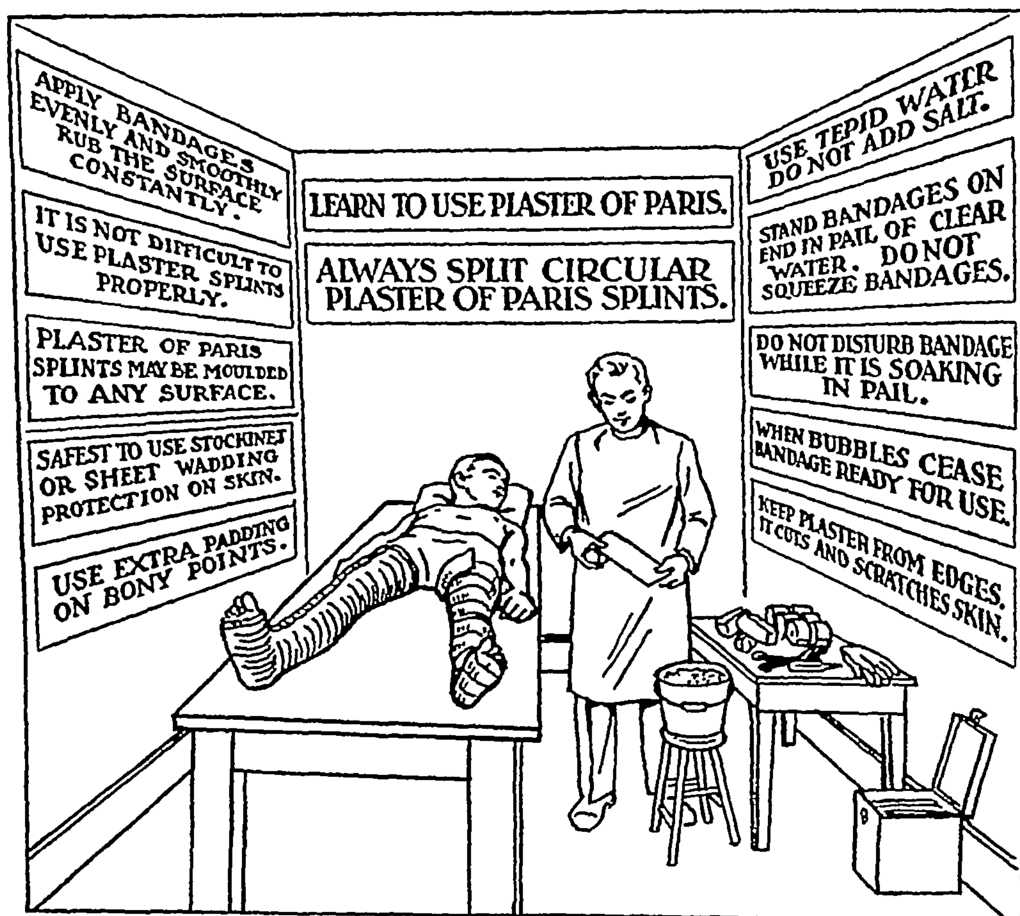


FIG 3 How to apply plaster of paris bandages

bandages while they are soaking. When air bubbles cease to rise from the submerged plaster bandage it is ready for use Grasp an end in each hand and compress gently, this removes the excess water but retains the plaster.

Apply the plaster bandage by unrolling around the properly prepared and padded part evenly without reversing, rubbing each layer smooth as it is applied The bandage should be applied without tension. If the plaster roll is kept close to the surface as it is

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applied one cannot create tension or undue pressure. Plaster splints may be reinforced by molded plaster, not with any other material. Do not make the plaster dressing too thick; one-fourth inch is usually sufficient. Split circular plaster of paris splints full length to allow for swelling. Molded splints of suitable size, unpadded or faced with a single layer of padding, may be bandaged in place while soft.

NOTES

FRACTURE OF THE NECK OF THE FEMUR

Fracture of the neck of the femur may be transverse or oblique.

Reduction.—Reduction may be accomplished with the help of anesthesia, local or general. An assistant should hold the pelvis steadily against the flat table during the maneuver. The flexed hip is lifted up with the patient supine and traction, internal rotation, abduction and complete extension of the leg are carried out. Reduction must then be checked by an anteroposterior and lateral roentgenogram of the hip before proceeding to immobilization

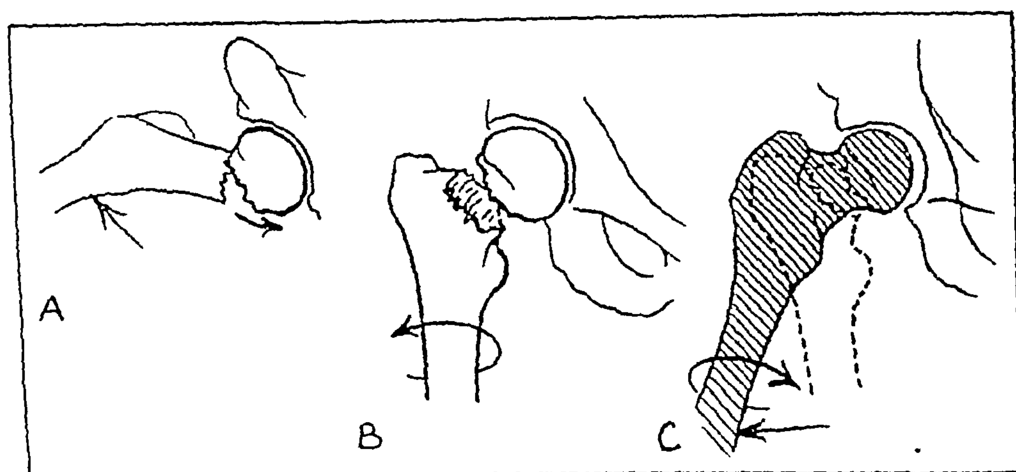


FIG 4 Fracture of the neck of the femur *A*, lateral view, *B*, anteroposterior view, *C*, reduction

Immobilization.—Immobilization after reduction may be maintained by an adequate plaster of paris dressing A double spica extending from the toes on the injured limb beyond the crests of the ilia and down to just above the knee on the well limb is preferable A supporting cross bar from knee to knee is necessary

The skin should be protected by adequate covering, such as stockinet or sheet wadding, or with special padding, such as felt, over bony prominences.

Immobilization by Internal Fixation.—It is also possible to use internal fixation to fasten a fractured hip. A flanged nail or several steel pins may be used for this purpose. The advantages of internal fixation are that prolonged after-immobilization in plaster is unnecessary, and the patient may become ambulatory on crutches after six weeks without bearing weight on the broken hip. The use of internal fixation, however, requires surgical experience, skill, an adequate armamentarium and roentgenologic control which must be closely coordinated with the entire procedure

NOTES

nstances, after internal fixation, a light plaster splint or balanced uspension of the leg in a splint may be required for a few weeks

After-Care—While the patient is confined to bed after fixation n plaster alone he must be turned on his side every two hours and on his face at least once in twenty-four hours to avoid pressure ores Immobilization must be maintained for from fourteen to

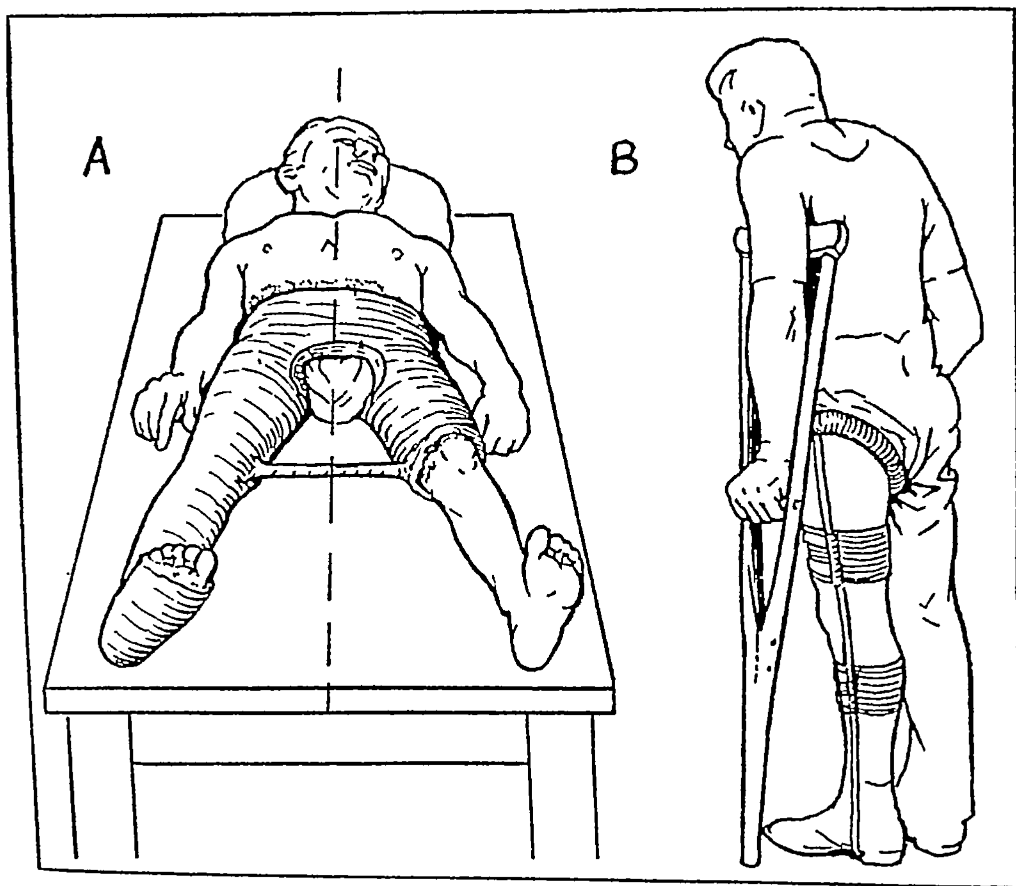


FIG 5 *A*, Immobilization plaster for fracture of the neck of the femur, *B*, Metal caliper splint for ambulatory after-treatment

twenty weeks, depending on the progress of healing as shown by roentgen examination Following internal fixation a much shorter period of plaster immobilization may be required.

When union is believed adequate for beginning weight bearing with crutches, no weight should be borne at first on the injured hip

Massage, passive and active motion and physical therapy should be used after removal of the plaster dressing The knee should be gently handled and not forced in passive motions

NOTES

FRACTURE OF THE NECK OF THE FEMUR

NONOPERATIVE TREATMENT

REDUCTION

Flex leg on thigh, thigh on trunk. Gentle traction upward. Rotate femur inward.

Then extend leg during abduction.

If reduction holds, foot will not evert. Vertical fractures may persistently evert when unsupported.

If foot everts, repeat manipulation; lessen abduction

AFTER TREATMENT

After reduction as shown by roentgenogram, anteroposterior and lateral, fix in double spica.

Fixation must be maintained until bony union is present—minimum period three months.

If internal fixation is indicated, same perfect reduction necessary.

Internal fixation may be obtained by nails, screws, pins or bone transplant.

Danger of infection, technical difficulties, experience of operator essential factors.

Delayed weight bearing insisted upon

Walking caliper often helpful

NOTES

INTERTROCHANTERIC FRACTURE OF THE FEMUR

An oblique fracture plane extends from one trochanter to the other, frequently with impaction, the lesser trochanter is often broken away, and there may be slight external rotation, with shortening of the leg. Internal fixation is rarely necessary and, when there are more than two fragments, may be harmful.

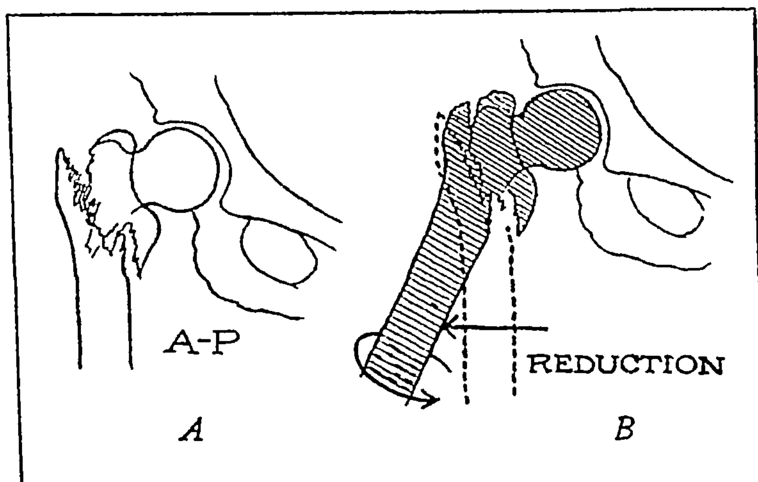


FIG 6 Intertrochanteric fracture of the femur *A,* displacement, anteroposterior view, *B,* reduction

Reduction —Reduction is accomplished with the help of anesthesia, local or general, by traction, abduction and slight internal rotation of the whole limb

Immobilization —Immobilization after reduction may be maintained by continuous traction in the long axis of the leg

Immobilization by internal fixation may be used under the restrictions advised for fracture of the neck of the femur

After-Care —While the patient is confined to bed in traction he may have enough freedom of motion to avoid pressure sores Immobilization by internal fixation may permit the patient to be out of bed sooner, to be lifted into a chair, or even to get about on crutches, not bearing weight on the fractured leg Every care must be exercised to avoid twisting the limb or undoing the approximation held by the internal fixation

When union is adequate for beginning weight bearing with crutches, the fracture may be protected for at least two additional months by the wearing of an elevation of 1 inch on the sole of the shoe of the well leg (see Fig 5)

NOTES

FRACTURE OF THE SHAFT OF THE FEMUR

A fracture of the femur may occur at any level of the shaft in a transverse, oblique or spiral plane, in any position bone fragments may be comminuted and in a small proportion open to the outside

Reduction —Reduction may be accomplished by continuous traction, primary adequate weight being used for adults by employing

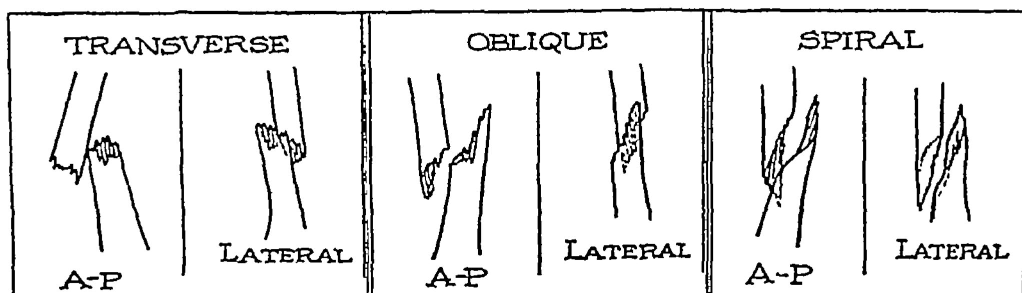


FIG 7 Fracture of the shaft of the femur

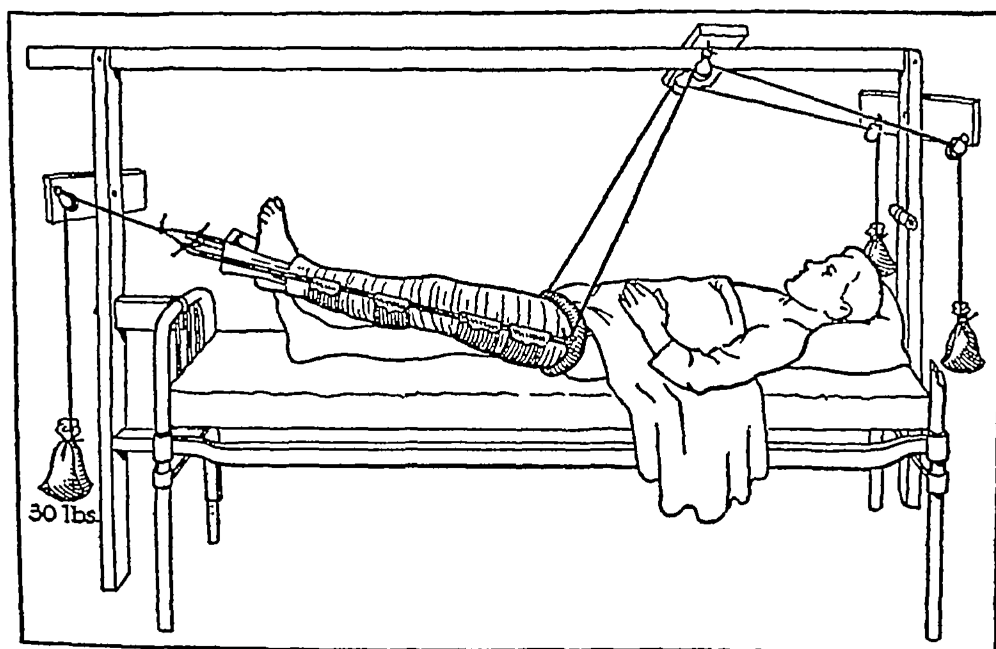


FIG 8 Suspension traction, fracture of the shaft of the femur

20 to 30 pounds in the first forty-eight hours if necessary, checking the position by roentgenogram Traction must be applied at the earliest possible moment even during treatment for shock, and may be applied as skin traction or skeletal traction For skin traction, apply adhesive tape to or slightly above the level of the fracture

NOTES

along the sides of the extremity while the leg is lifted and gently held by traction on the foot. The adhesive tape should be held in place by an elastic roller bandage The ends of the tape, extending beyond the foot, are fastened to a thin oblong wooden block perforated in the center, through this perforation the traction rope passes and is fastened to the end of the Thomas splint (see Fig. 8) Direct skeletal traction may be secured by perforating pin or wire applied aseptically through the distal end of the femur, the upper end of the tibia or through the heel Whether skin or skeletal traction is employed, the extremity must be suspended in a Thomas or a Hodgen splint

Immobilization.—The suspension traction described alines the bone, affords sufficient immobilization, facilitates nursing care and adds to the comfort of the patient.

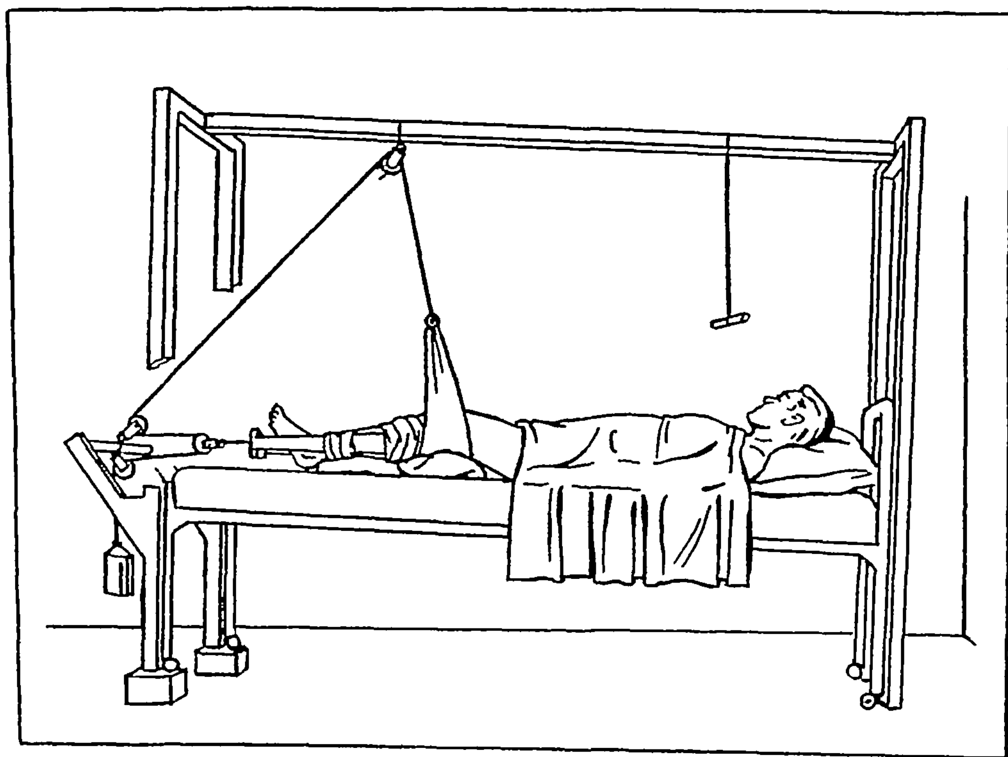


FIG 9 Suspension traction, fracture of the shaft of the femur (Russell)

After-Care—The position of fragments should be checked by the end of the third day of traction by roentgen examination in both the anteroposterior and lateral planes and at suitable intervals subsequently until the fracture consolidates If satisfactory reduction has not been secured within three days, consultation is advisable Suspension traction must continue to be applied efficiently for at

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least ten weeks, after which time, if the roentgenogram shows consolidation, a splint for ambulatory treatment is necessary. This may be an encircling plaster of paris splint immobilizing both knee and hip and extending from the iliac crest to the base of the toes, or a suitably designed metal caliper with a protecting leather sleeve over the fracture site. The accessory splint must be worn in conjunction with crutches until union is solid and all danger of secondary deformity is past. After sufficient bony callus has formed to permit removal of apparatus, in efforts to restore knee joint motion caution must be exercised not to throw undue strain on the recently built callus of the femur. The patient should attempt to flex the knee while lying on the fractured side, rather than to force leg flexion sitting on a table edge, thus limiting the leverage force applied to the fracture site.

NOTES

FRACTURE OF THE SHAFT OF THE FEMUR

Fractures may be open or closed.

Open fractures require immediate surgery.

Shaft fractures may be transverse, oblique, spiral or comminuted.

Continuous traction reduces most shaft fractures.

Watch out for overpull of fragments producing distraction. Check by portable X-ray.

Complete bony union advisable before weight bearing.

Supporting walking caliper always required in early weight bearing to prevent secondary deformity. Use protective leather sleeve over fracture site.

Knee function often restricted after fracture is united although no fracture in joint.

Periarticular infiltration of blood from fracture and long immobilization to secure bony union act unfavorably on knee.

NOTES

FRACTURE OF THE TIBIA AND THE FIBULA

Fracture of the tibia and the fibula may be transverse, oblique or spiral, any type may be comminuted.

Reduction.—Reduction may be accomplished by manual or fracture table traction and manipulation and pressure with the aid of anesthesia, local or general, or by continuous skeletal traction with pin or wire through the bones of the leg or os calcis and immediate application of weight for traction Reduction must insure reestablishment of the weight-bearing and knee or ankle joint lines

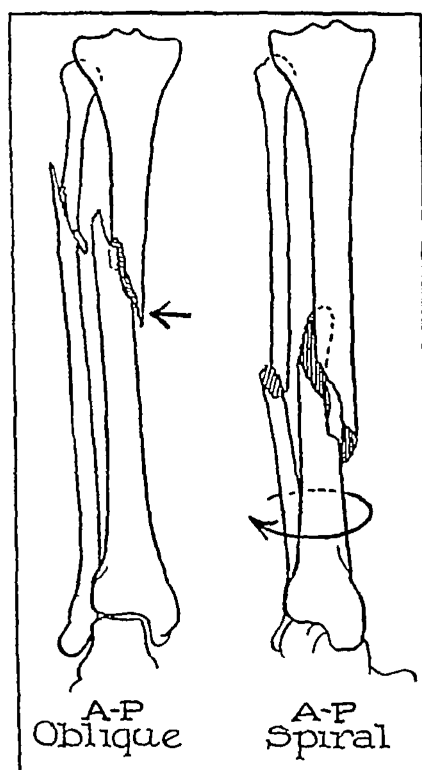


Fig 10 Fracture of the tibia and the fibula

Immobilization—This may be maintained by a plaster of paris dressing, either circular or molded, on the posterior and lateral aspect of the extremity, extending from the toes to the groin. However, oblique or spiral fractures usually require continuous traction until bonily annealed All bony prominences must be padded to avoid pressure. Pressure of a plaster splint on the head of the fibula may cause peroneal paralysis To avoid any posterior bowing after fractures of both bones of the leg, a support under the leg by means of a square sand bag or hand support must be employed during the process of plaster setting If immobilization is secured by skeletal

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traction and suspension, a Thomas leg splint is employed (see Fig. 8). Its use must be continued for from six to seven weeks or until beginning bony consolidation is shown by roentgen examination in two planes.

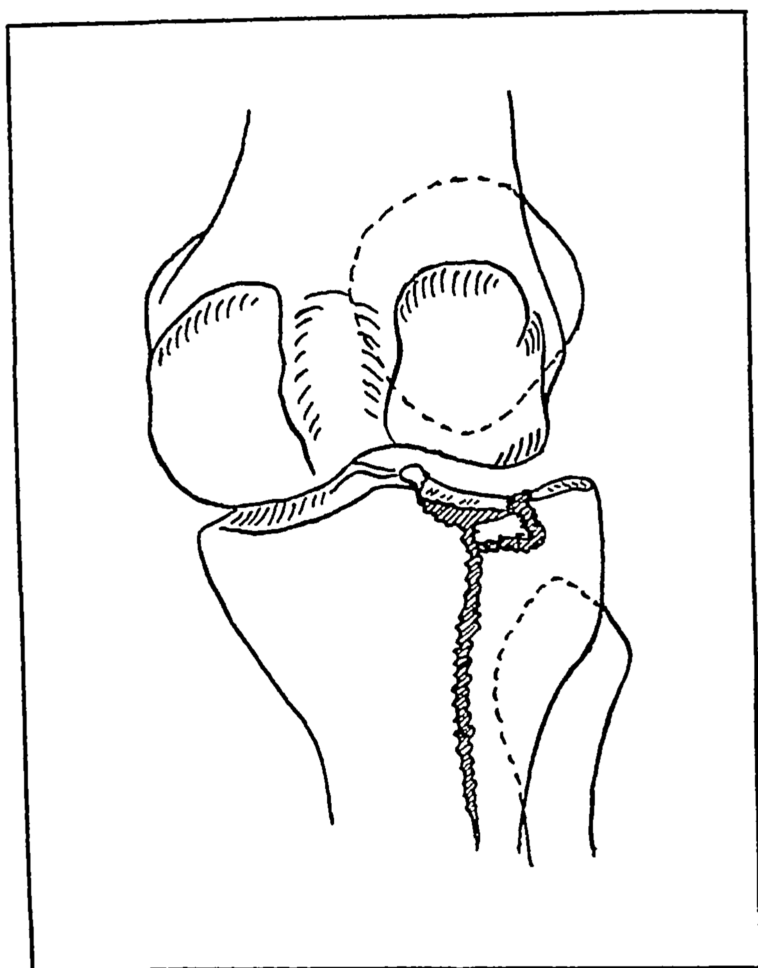


FIG 11 Bumper fracture at knee involving head of tibia from direct violence (as from the bumper of automobile) Tibial joint surface and cartilage broken into and usually depressed to change axis of joint.

After-Care—The position of fragments should be checked by roentgenograms in two planes after the application of the plaster of paris dressing following reduction by manipulation, and it should be rechecked at least twice during the course of treatment to insure the maintenance of position. When skeletal traction is used, immediately after removal of the apparatus, the position of fragments is affirmed by roentgenogram, and a circular plaster of paris dressing is applied Full weight bearing on the fractured extremity should not be permitted until firm bony union is shown This will usually be from ten to fourteen weeks after the fracture occurred A walk-

NOTES

ing iron stirrup may be imbedded in the plaster used for treatment of well-reduced transverse fracture only.

Although the principal points to cover in the treatment of fractures of the tibia and fibula are length of the limb, muscular control of the foot and axial alinement, the first point is less important than the other two Most important is maintenance of a normal axis of the leg in both planes to avoid lateral displacement, or bowing,

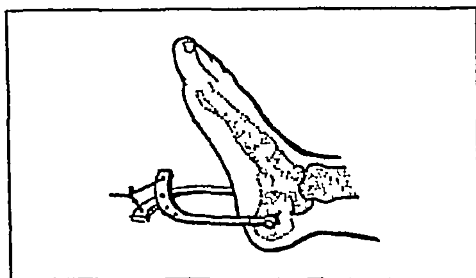


FIG 12 Steinmann pin or Kirschner wire through the calcaneus These must be inserted from the inner side of the foot outward

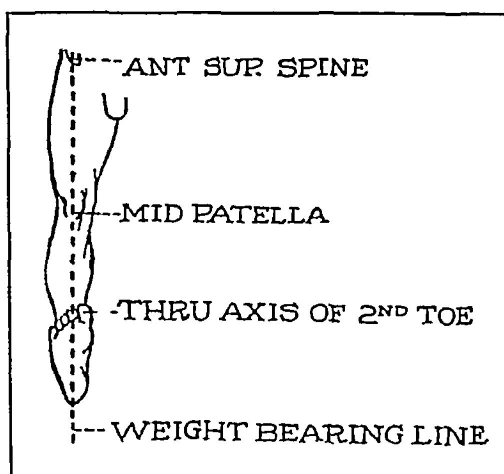


FIG 13 Normal axis of the leg

and sagging, or posterior dishing. Posterior bowing is more disabling than the same degree of anterior bowing. Likewise, medial bowing is more crippling than the same amount of lateral bowing Lack of correct alinement in the bones of the leg and power to use the foot for propulsion or standing are difficult to compensate, whereas a slight shortening can be overcome by an extra thick sole and heel on the shoe If union is delayed, a walking caliper which does not permit ankle motion and maintains length of leg may be employed

NOTES

FRACTURE AT THE ANKLE

Fracture at the ankle may become very disabling and requires exactness in reduction. The fractures may be classified as

1. Isolated fractures of the malleoli
2. Bimalleolar fractures
3. Fractures of the lower articular surface of the tibia
   (*a*) Anterior lip or margin
   (*b*) Posterior lip or margin
4. Any or all of these may be accompanied by anteroposterior or rotatory dislocation

Both anteroposterior and lateral roentgenograms are necessary for diagnosis. Often an oblique view is required in addition to reveal any unusual fracture or displacement

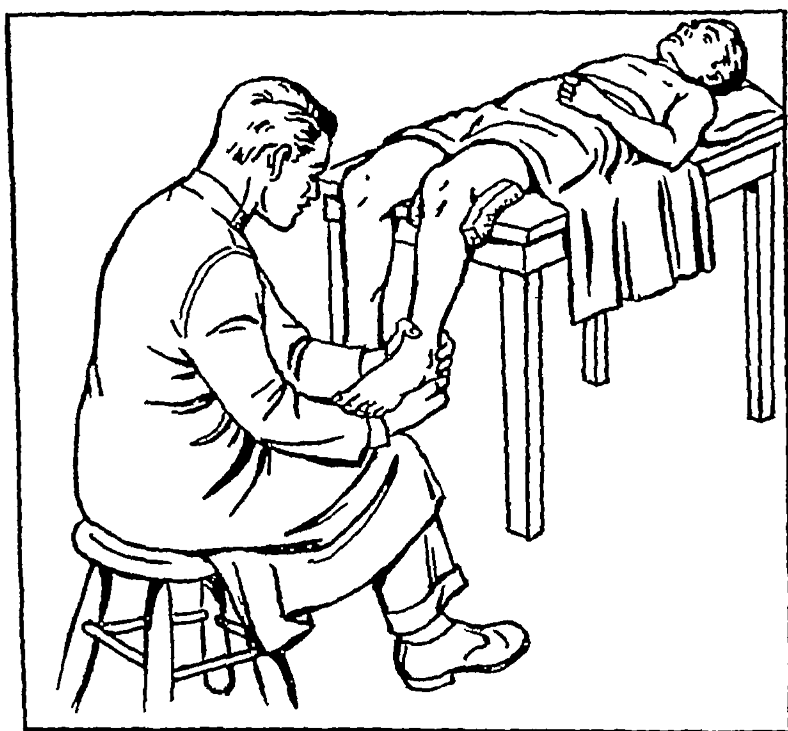


FIG 14 Reduction, fracture at the ankle

Reduction —After the foot is cleansed with soap, water and alcohol, reduction is carried out by manipulation with the help of anesthesia, either local or general, with the patient lying on his back if assistance is lacking and the knee flexed over the end of the table. The leg is grasped firmly with one hand just above the malleoli, the other hand grasps the foot well posteriorly around the heel, and the displacement is reduced by manipulation. This applies to mal-

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leolar fracture only. When there is a posterior marginal fracture, with backward displacement of the foot on the ankle, in addition to this manipulation, the foot must be pulled forward to reduce the posterior dislocation and be brought into a right-angle relation with the leg to restore the normal contour of the lower articular surface of the tibia. This reduction should be checked at once by roentgen examination in two planes, and exact restoration of the ankle mortise and of the lower articular surface of the tibia must be obtained The position must be rechecked in three weeks.

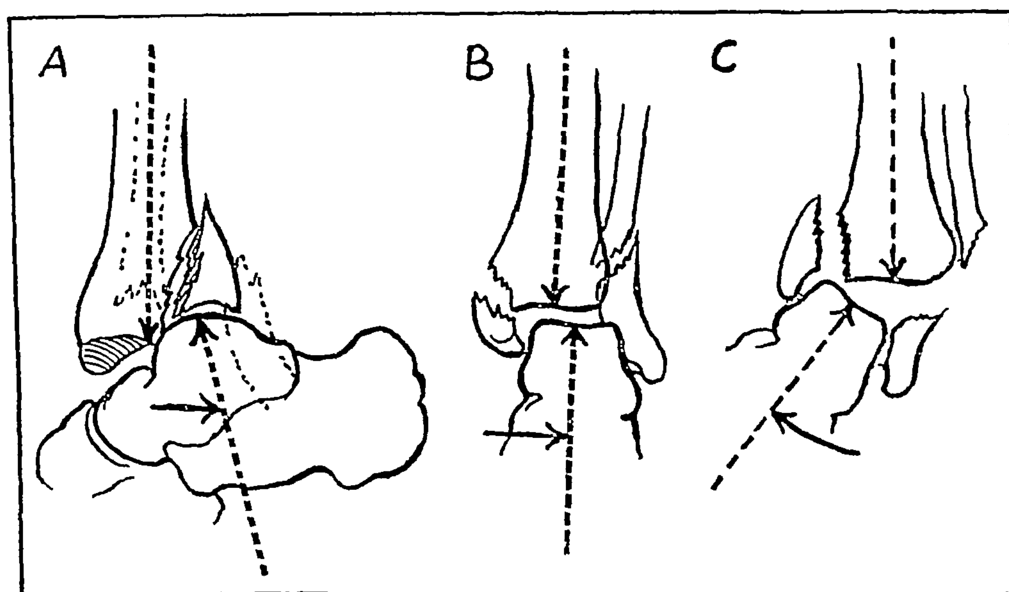


FIG 15 Fracture at the ankle *A,* backward displacement, *B,* outward displacement, C, inward displacement.

Immobilization—Immobilization is secured by a circular plaster of paris dressing This may be molded by hand pressure to fit the malleoli snugly over the usual leg covering of stockinet and sheet wadding. For the fracture of the posterior lip, the plaster dressing should extend above the knee and the leg should be fixed with the knee in moderate flexion Most patients with any type of fracture about the ankle are more comfortable with one to two weeks fixation of the knee, if plaster dressing is used

Except in the case of posterior marginal fracture, a walking iron stirrup may be incorporated in a new plaster of paris dressing eight weeks after the original injury and partial weight bearing permitted. Prior to this change of plaster dressing, checking roentgenograms for position of fragments and formation of callus should again be made.

NOTES

After-Care.—Fixation should be maintained for from ten to sixteen weeks and then be followed by massage and active motion if union has developed

In a large proportion of cases of fracture of the ankle, deformity will recur if weight bearing is allowed too soon; unprotected walking should therefore not be allowed until solid bony union is present, as shown by roentgen examination. The tendency of the posterior dislocation of the foot to recur after reduction and application of fixation for a posterior marginal fracture should be constantly borne in mind.

When exact reduction has not been obtained by manipulation, skeletal traction through the calcaneus may often be used with advantage, especially for fracture of the posterior lip In such a situation, consultation is advisable

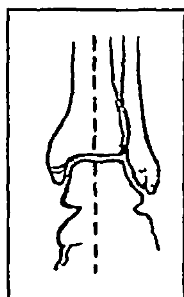


FIG 16 Normal mortise of the ankle

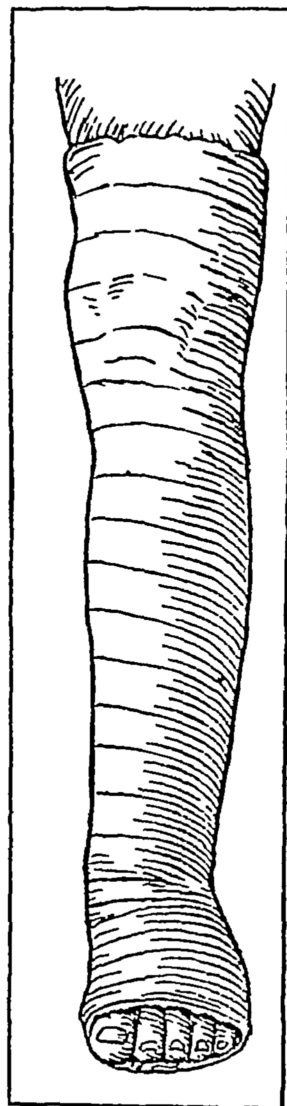


FIG 17

FIG 17 Plaster dressing for immobilization, fracture at the ankle, foot in weight bearing line and at right angle to the leg

NOTES

FRACTURE OF THE CLAVICLE

The common type of fracture is in the middle third of the clavicle, the plane of fracture may be transverse or oblique and comminution may exist. Fracture of the clavicle weakens the normal support of the shoulder and allows it to fall forward, downward and inward.

Palpation will show overlapping and elicit local tenderness, and roentgenograms will reveal the fracture and the degree of displacement of the fragments An infant will not use the arm on the side of the fracture and will hold the head inclined toward the shoulder of the injured side.

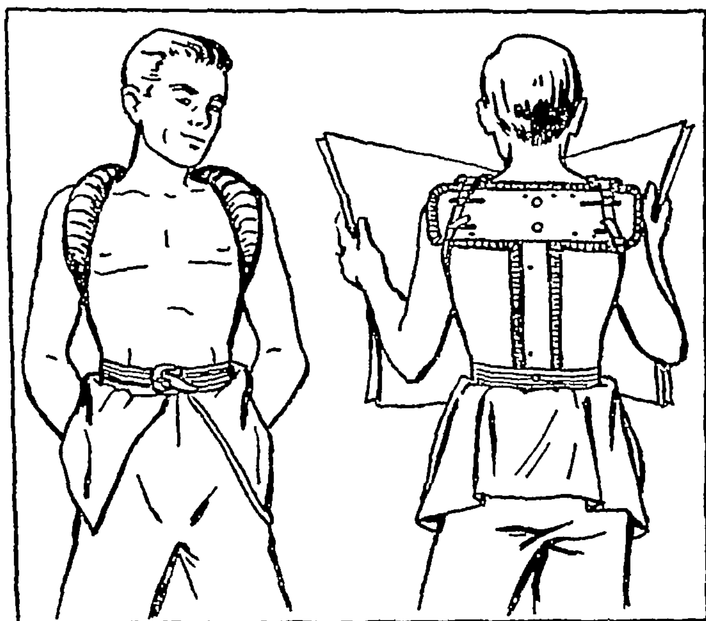


FIG 18 T splint for immobilization, fracture of the clavicle

Reduction and Immobilization—Complete reduction is often difficult to secure and to maintain, but the results are usually good functionally However, in an adult with considerable overriding of the fragments, shortening of the bone results and may impair the mechanics of the shoulder joint. The best reduction is secured by recumbency in bed without pillows, a pad should be placed between the shoulder blades and the arm on the fractured side allowed to hang unsupported over the edge of the bed.

If the patient is to be ambulatory, reduction can be secured and maintained by the use of a padded T splint or a figure of eight plaster dressing In applying either of these splints, the shoulder must be lifted upward and backward and the splint adjusted snugly

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to maintain this position. Adequate padding must be used under the plaster figure of eight bandage and no rough plaster edges should rub on the skin surface. The T splint will require frequent inspection and adjustment (see Fig. 18).

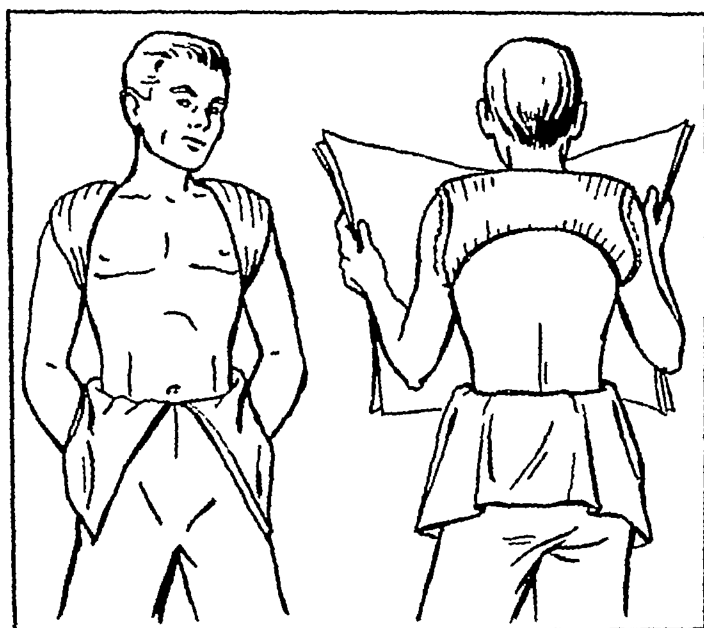


FIG 19 Plaster of paris figure of eight bandage, well padded beneath to prevent skin irritation, used for fracture of the clavicle.

After-Care.—If the patient is treated in recumbency, three weeks should be adequate, after which he becomes ambulatory and the arm should be supported for at least three weeks longer in an arm sling. If ambulatory treatment is employed primarily, the supporting splint should be worn for at least four weeks and then an arm sling for at least three additional weeks.

If the reduction fixation of the fragments is adequate, voluntary movements of the whole arm should be encouraged from the beginning.

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FRACTURE ABOUT THE UPPER END OF THE HUMERUS

Fracture of the neck of the humerus, anatomical or surgical, occurs commonly in elderly individuals. It may be either impacted

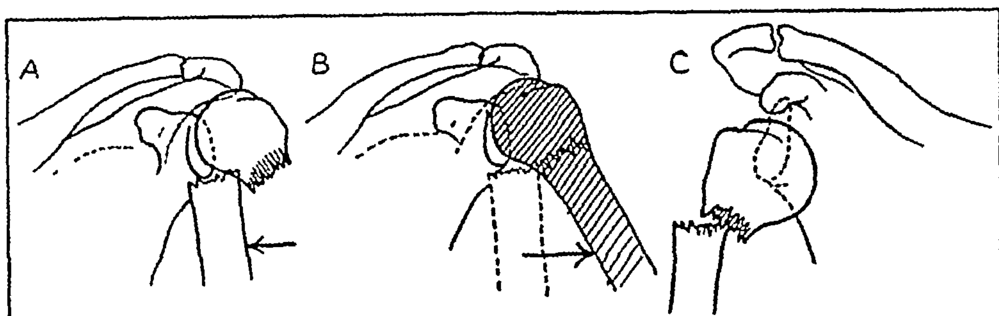


Fig. 20. Fracture about the upper end of the humerus *A,* displacement, *B,* reduction; *C,* fracture dislocation at the upper end of the humerus.

Fig 21 Suspension traction for reduction and immobilization, fracture about the upper end of the humerus

or not. The usual deformity consists of adduction and overriding with upward displacement of the distal shaft fragment and abduction and external rotation of the proximal head fragment

NOTES

For transportation the sleeve holding the arm should be lightly pinned to the clothing on the body with the elbow flexed. Immediate roentgen examination of a fracture of the shoulder joint must be insisted on, because the fracture is frequently complicated by a dislocation of the head of the humerus. As with all fractures, the primary examination should include a check of the blood and nerve supply of the extremity, and this should be recorded in writing. All manipulation of the extremity before roentgen examination should be avoided because of the danger of injury to soft parts, blood vessels or nerves and the breaking up of impaction of undisplaced fragments.

Reduction.—No reduction is required when the fragments are impacted and are in a satisfactory position Suspension in a sling for two to three weeks may give satisfactory results, guarded voluntary movements may be permitted after two weeks.

When displacement of fragments is present, rapid reduction may also be secured by the use of a hanging cast (see Fig. 22).

When there is considerable overriding of the fragments or when

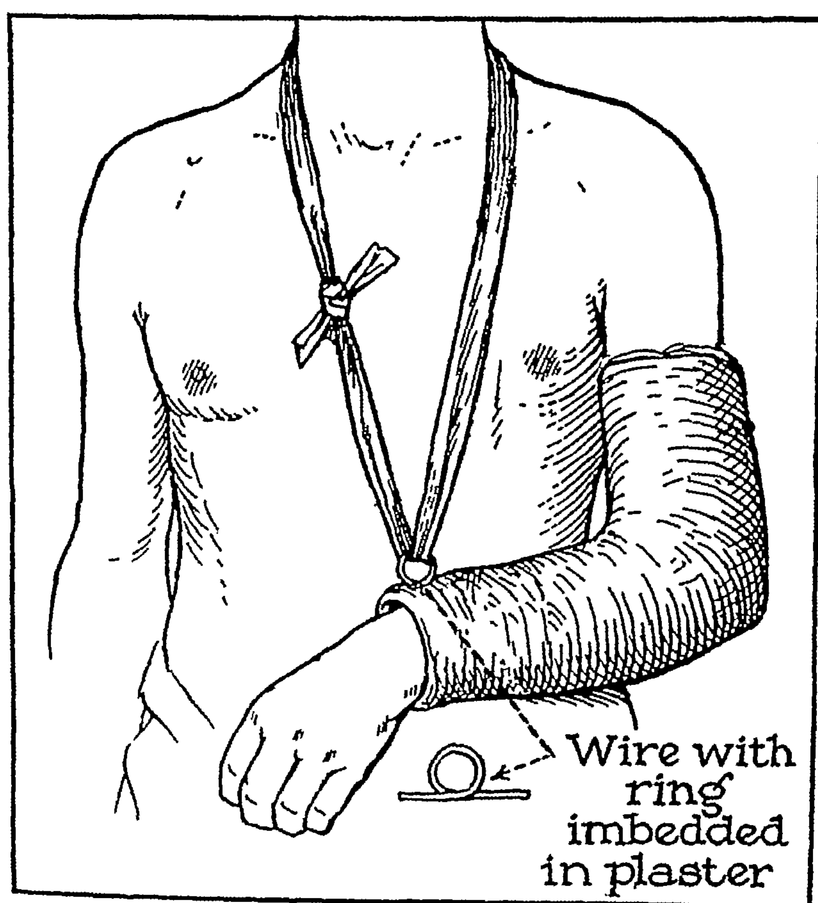


FIG 22 Hanging cast for fracture of humerus

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primary reduction has been unsuccessful, traction in recumbency usually gives a satisfactory result. The arm should be placed in a position of external rotation and sufficient abduction to aline the fragments as shown by roentgenograms (see Fig 20). When suspension and traction are employed, recumbency should last for five or six weeks, after which a molded plaster splint or sling should be used, depending on the character of the union

THE HANGING CAST. Ambulatory treatment with traction may consist of a hanging circular plaster cast, average weight 2½ to 3 lbs, extending from the wrist to below the axilla. This is applied over stockinet and suitable padding, with the forearm flexed at approximately right angles to the arm midway between pronation and supination and supported by a permanent cloth sling about the neck. This is inserted through an imbedded metal ring at the wrist which retains this position (see Fig 22) Early movements at the shoulder region are encouraged by swinging the suspended forearm The weight of the plaster dressing itself acts as a constant traction to pull the bone fragments into alinement. Distraction must be avoided A high pillow or semirecumbent position should be assumed at night.

In delayed reduction to be obtained by traction with weights, the patient's arm is suspended in traction as he lies in bed, as shown in Figure 20.

After-Care —Hanging casts are worn from six to eight weeks or until there is clinical evidence of bony union Light use of the arm then begins, wearing it suspended part time in a broad muslin sling around the neck for a final two weeks.

NOTES

FRACTURE OF THE SHAFT OF THE HUMERUS

All manipulations of the extremity before roentgen examination should be avoided because of the danger that the displaced fragments may cause injury to the soft parts, blood vessels or nerves

The most satisfactory temporary immobilization for transportation is obtained by pinning the sleeve to body clothing, elbow usually flexed.

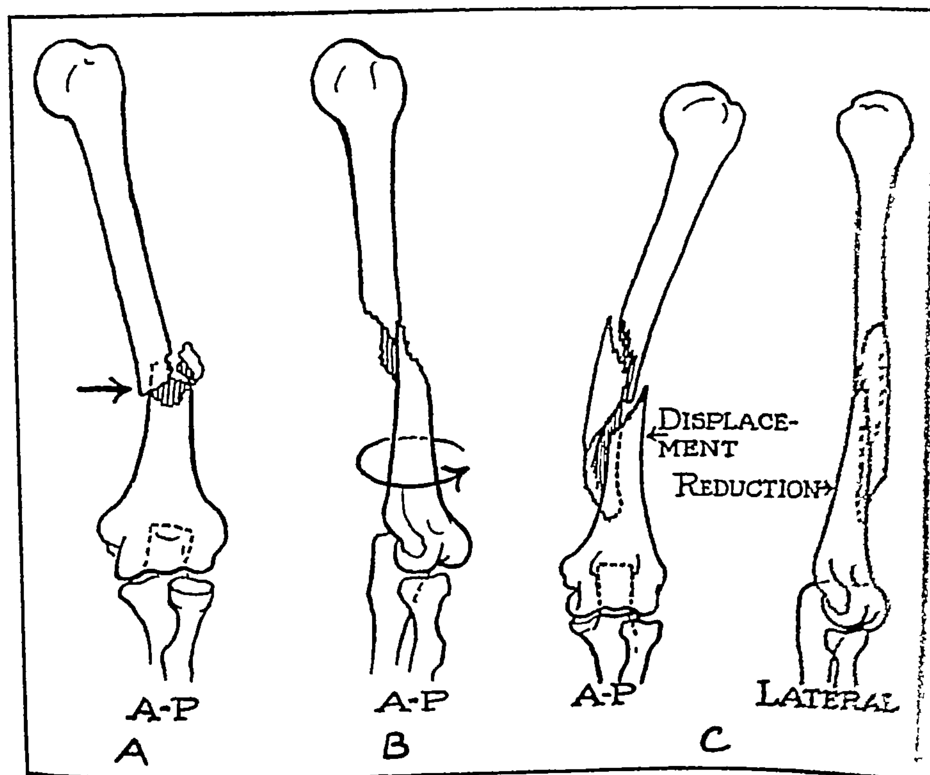


FIG 23 Fracture of the shaft of the humerus *A*, transverse; *B*, spiral; *C*, comminuted

The whole extremity may be bound gently to the side of the body in a position of extension in instances of fracture at the lower end of the humerus

Fracture of the shaft of the humerus occurs most frequently about the middle third, it may be transverse, spiral or comminuted

Because of the proximity of the musculospiral nerve to the humerus in its middle third, injury of this nerve is not uncommon and this complication should not be overlooked at the primary examination Certainly the presence of wrist drop, or other evidences of interference with the radial nerve, should be recorded in writing This primary record may protect both doctor and patient

Reduction —Because of the difficulty of maintaining the reduction, gentle traction must be continued for a long time. The use of

NOTES

the hanging cast (see Fig 22) fulfills this requirement in most instances. Here again distraction must be guarded against.

Fractures of the shaft of the humerus are best treated by persistence in the use of the hanging cast and checking both position of the bone and appearance of callus by roentgenogram. If failure to reduce the fracture is acknowledged, traction by weight while the patient is in recumbency may be tried. Such an attempt must not be postponed too long or until after callus has formed to maintain an angulation or overriding.

If treated in recumbency, the extremity should be placed in the degree of abduction and rotation which will aline the fragments properly, as determined by roentgenograms. While skin traction will be adequate in the majority of cases, powerful skeletal traction obtained by passing a wire through the olecranon may be necessary.

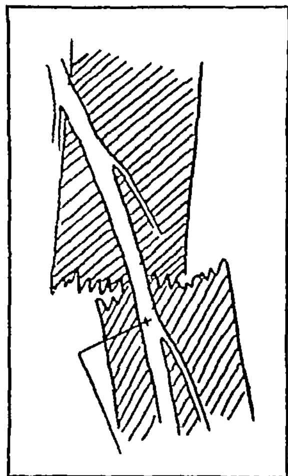


Fig 24 Fracture of the shaft of the humerus, relation of the musculospiral nerve to the fracture

After-Care—The hanging cast should be worn six to eight weeks, removed after confirmation of bony union by roentgenogram.

The use of the hanging cast in fractures of the shaft of the humerus in children often fails; therefore, the use of traction in recumbency or of molded plaster of paris carried well up over the shoulder above and into the palm of the hand below may be required.

When suspension and traction are employed, recumbency should last for at least four weeks, the length of time depending on clinical and roentgen evidence that adequate callus has formed A two-piece molded plaster splint should then be applied, one piece extending from the axilla on the anterior surface of the arm and the other from beyond the tip of the shoulder on the posterior surface to the flexion crease of the palm, the forearm being at right angles with the arm The after-treatment following application of a plaster splint subsequent to recumbent treatment is the same as that used when the splint has been worn from the beginning of treatment

The shaft of the humerus is a common site of nonunion. This may follow a lack of persistence in use of the hanging cast or of traction in recumbency, especially if any overpull of fragments has occurred, establishing a hiatus between them New bone will seldom form over such gaps.

NOTES

SUPRACONDYLAR FRACTURE OF THE HUMERUS

The most frequent fracture about the elbow joint is in the supracondylar region of the humerus This fracture occurs more often in children than in adults. The line of fracture may be transverse, oblique (downward and forward) or comminuted. The distal fragment is almost always displaced posteriorly, and there is usually some lateral displacement. Injuries of the soft tissues, blood vessels or nerves frequently complicate this fracture.

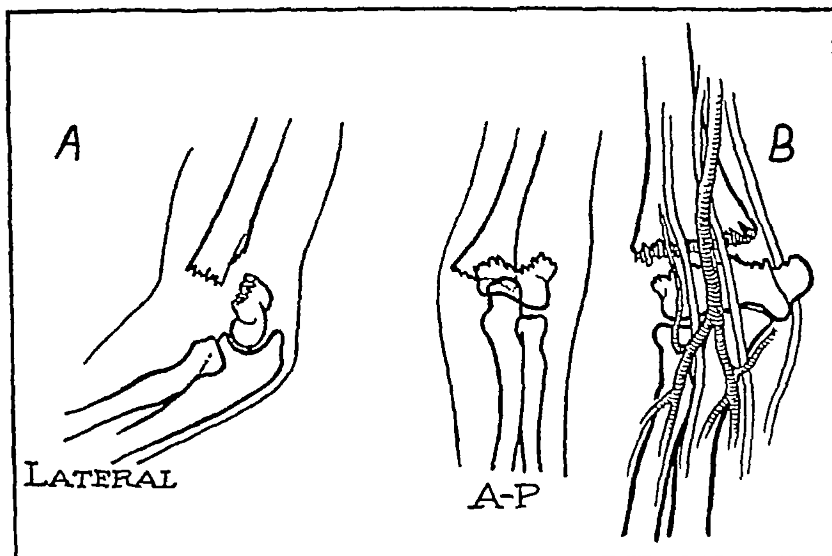


FIG 25 *A*, supracondylar fracture of the humerus; *B*, arteries and nerves at the elbow joint.

Volkmann's type of ischemic contracture of the forearm and hand may be due to injuries of blood vessels and nerves and the presence of the hematoma which forms about the fracture retained within the fascial envelope of the arm It occurs most frequently as a complication of fracture in the elbow region. Unless this complication is promptly recognized and relieved, permanent deformity of the elbow, forearm and hand may result Therefore, with a fracture about the elbow, special care should be taken at the time of the primary examination to rule out impairment of circulation, motor power and sensation in the forearm and hand Ischemic contracture may develop within the first few hours after reduction and splinting, consequently, blanching or cyanosis of the hand, intense edema, change of temperature or sensation, such as numbness, or absence of radial pulse call for immediate action The pressure of the dressing outside the arm and of the hematoma within the arm

NOTES

must be released by extension of the forearm, followed by elevation of the arm or fasciotomy after surgical consultation.

Reduction—Immediate reduction with the help of general anesthesia is indicated, as delayed reduction increases the difficulty of obtaining accurate apposition of the fragments and enhances the danger of interference with the blood and nerve supply Reduction may be secured by traction to unlock the fragments, countertraction being maintained by an assistant. The forearm is then brought into

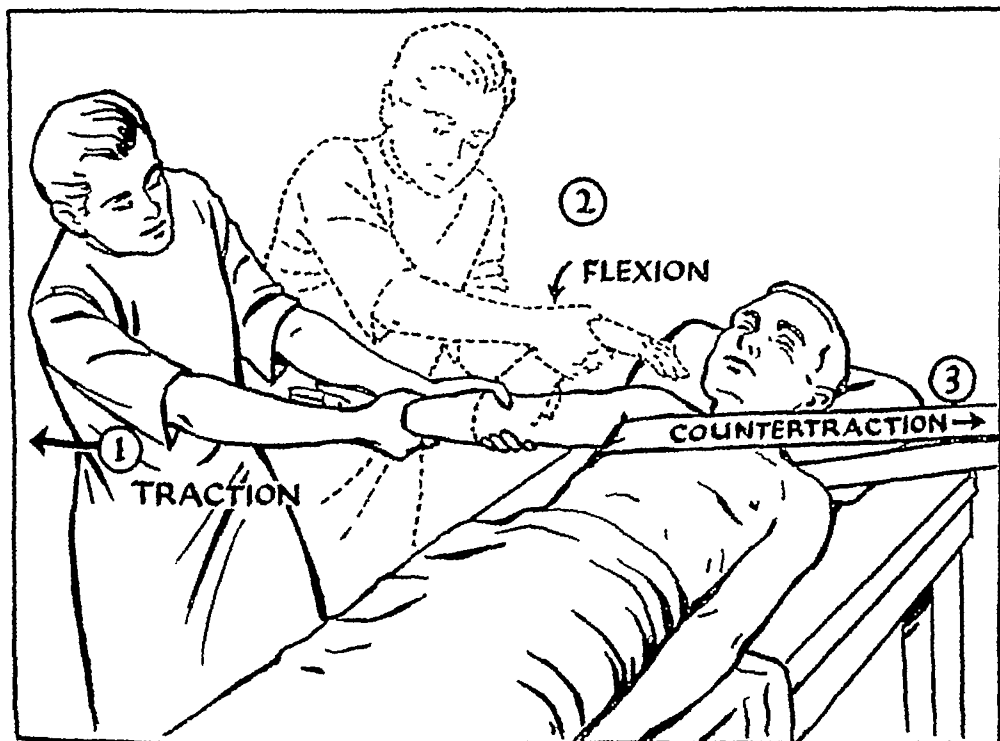


FIG. 26 Reduction, supracondylar fracture of the humerus.

flexion, with its long axis directly overlying the long axis of the humerus, to overcome lateral displacement and preserve the normal carrying angle. This reduction must be immediately checked by roentgen examination, with anteroposterior and lateral views. When complete reduction has been obtained, pulsation in the two radial arteries should be compared, and if the radial pulses are not equal, the degree of flexion at the injured elbow should be decreased until they are If this change in position results in a recurrence of the displacement of the fragment, consultation should be sought.

Skeletal traction through the olecranon may be required, along with recumbent treatment for fractures difficult to reduce or those complicated by great edema or circulatory interference.

NOTES

Immobilization.—This is best maintained by a two-piece padded anterior and posterior molded plaster splint bandaged on and extending from the level of the shoulder and axilla to the heads of the metacarpal bones with the forearm in full supination and its long axis supported directly over that of the arm.

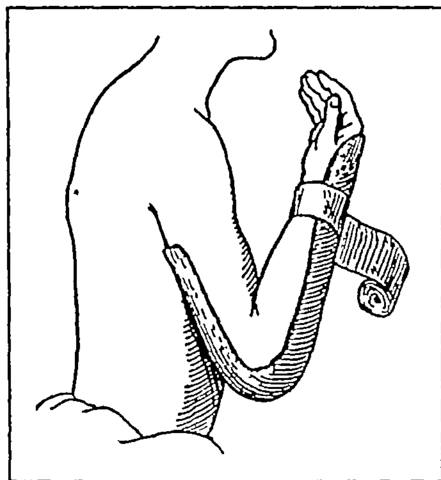


FIG 27. Immobilization, supracondylar fracture of the humerus

After-Care—Adequate after-care demands daily inspection and checking of the circulation and sensation of the forearm and hand and of the integrity of the splint Immobilization should be maintained for four or more weeks At the end of this period the arm should be supported in a sling and active use gradually resumed Violent manipulations of the joint should be avoided, as they delay recovery and may cause excessive formation of new bone, induce secondary displacement and permanent impairment of articular function Local heat followed by gentle massage of elbow and arm will aid recovery. Absolutely no forced active movements of the elbow joint should be indulged in The patient must be taught to relax his biceps muscle and employ active movements of the forearm and elbow without setting up painful reaction

NOTES

FRACTURE OF BOTH BONES OF THE FOREARM

Fracture of both bones of the forearm which involves the elbow joint is serious and carries with it the danger of permanent impairment of function of the elbow joint. It requires special methods of treatment, and the responsibility should usually be shared with a consultant.

The fracture planes may be transverse, oblique or comminuted. Fracture of both bones of the forearm in the middle third may lead to overriding, angulation and rotation of all four fragments. In children, greenstick fractures are frequently seen Although there is

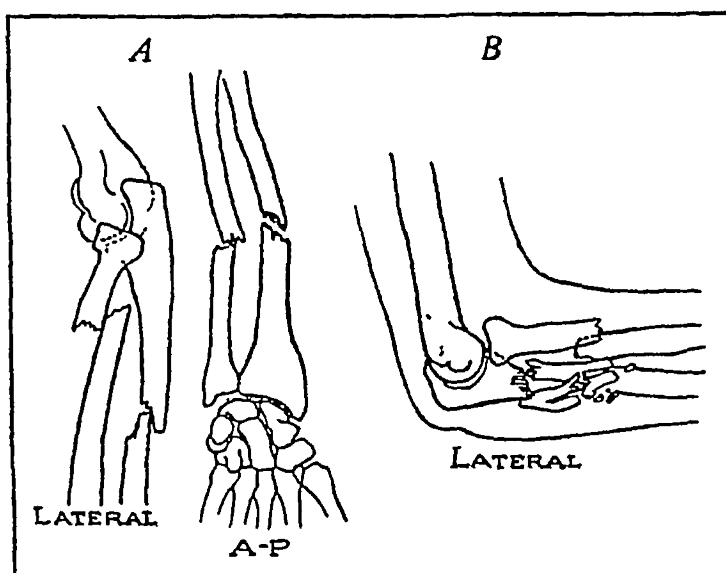


FIG 28 Fracture of both bones of the forearm *A,* transverse, *B,* comminuted.

usually no gross displacement, they should be brought into a straight line by manipulation under anesthesia and exactly reduced if possible. If this is not done, angular deformity almost always results but the growth of the child may overcome this.

Reduction.—Immediate reduction should be carried out with the help of general anesthesia With the elbow flexed to 90 degrees, reduction may be obtained by traction and countertraction, rotation and molding The position of the fragments after reduction should be observed in two planes roentgenographically Traction should be continued during roentgen examination and until the fracture is immobilized.

When satisfactory alinement of both bones cannot be obtained and demonstrated by roentgenograms in two planes, functional disability may result and the responsibility of treatment should be

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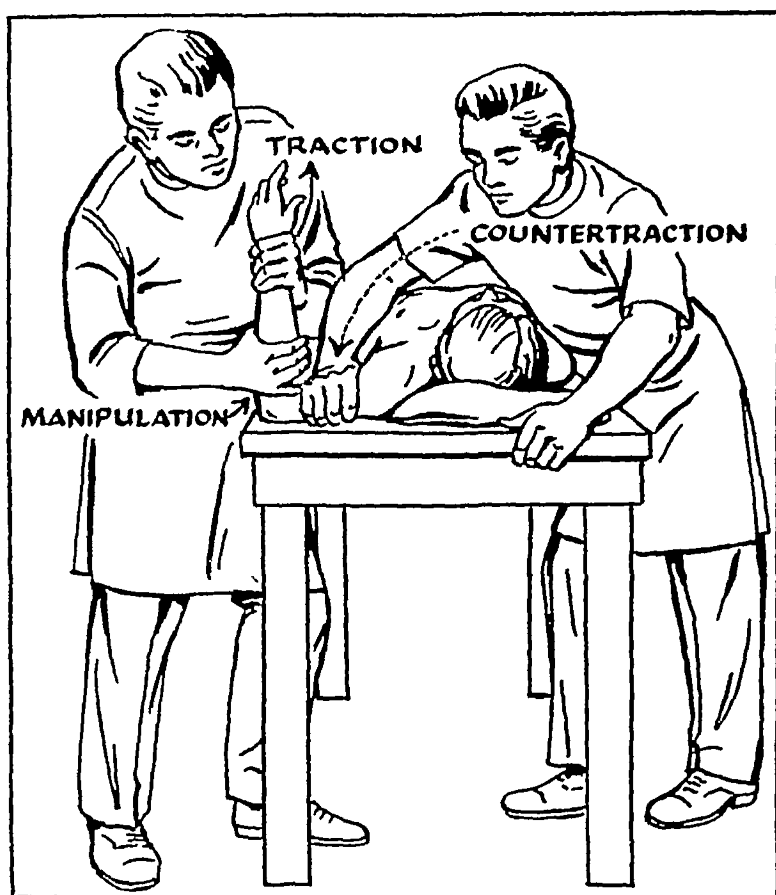


FIG 29 Reduction, fracture of both bones of the forearm

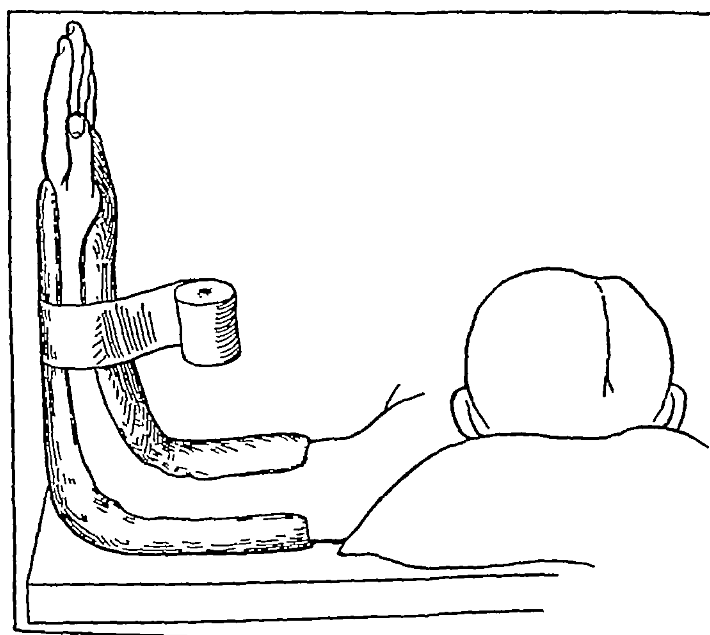


FIG 30. Immobilization, fracture of both bones of the forearm

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shared with a consultant This applies particularly to overriding and rotation of the shaft of the radius.

Immobilization.—This is best obtained by molded anterior and posterior plaster splints applied from the level of the axilla to the heads of the metacarpal bones with the elbow at an angle of 90 degrees The forearm is supported in such a position of pronation or supination as best preserves the reduction, this is usually midway between pronation and supination.

After-Care.—Immobilization should be maintained for ten or twelve weeks. No movement of either active or passive pronation or supination should be allowed until after the tenth week. Every five days for the first two weeks after immobilization, the position of the fragments and, later, the development of the callus should be checked roentgenographically, as deformity can occur as the result of muscle pull during consolidation and with splints in place.

NOTES

COLLES' FRACTURE

Fracture of the lower end of the radius is often characterized by silver fork deformity of the wrist, with a radial deviation of the hand The fracture occurs about three-fourths of an inch above the wrist, the plane of fracture is usually transverse but may be oblique or comminuted The distal fragment is usually displaced posteriorly and laterally, and the axis of the radiocarpal joint is tilted dorsally. The fragments are frequently impacted

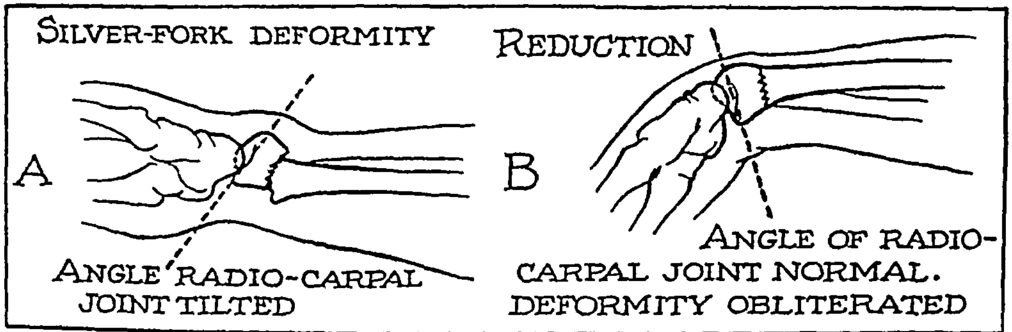


FIG 31 Fracture of the lower end of the radius *A,* displacement, *B,* correction

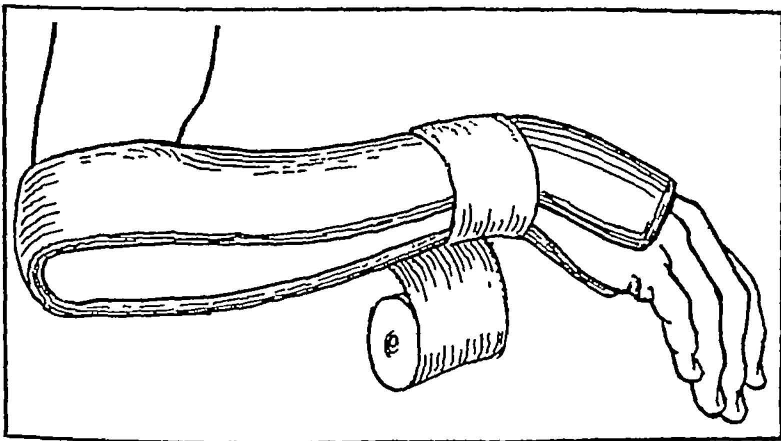


FIG 32 Immobilization, Colles' fracture, sugar tongs splint

Reduction—Immediate reduction should be carried out with the help of anesthesia, local or general, delayed reduction adds to the difficulties of securing accurate replacement Reduction may be secured, first, by the use of traction on the hand to break up the impaction if present Second, in some instances gentle hyperextension is necessary to break up impaction The wrist is then brought into full flexion during traction, with the hand in ulnar deviation. The fracture cannot be properly reduced unless the impaction is pulled out The position of fragments should be checked by anteropos-

NOTES

terior and lateral roentgenograms. Complete reduction is shown by restoration of the normal axis of the radiocarpal joint and reestablishment of the normal level relationship of the radial and ulnar styloid processes

Immobilization.—This is best secured by anterior and posterior splints of molded plaster of paris, applied with the reduced wrist held in flexion and the hand in ulnar deviation. The plaster dressing should include the arm above the elbow for at least a week, after which period the portion above the elbow may be removed. This assures greater comfort, fixation and security.

After-Care.—The position of flexion of the wrist should be maintained for at least three weeks. A new molded splint may then be applied with the wrist in a neutral position, i.e., straight with forearm, but this second dressing must be applied without any movement of the bone fragments. The thumb is left free. This should be worn for an additional three or more weeks depending on the amount of comminution, during which period massage and guarded active movements may be allowed under the personal supervision of the doctor, hyperextension at the wrist being avoided. The splint is removed only for the short period of such treatment. At all times during treatment, active movements of the joints of the fingers and thumb should be encouraged Snug wrapping of the thumb and fingers by a narrow gauze bandage in the first three or four days after fracture may aid in avoiding stiffening or disabling edema. This enhances but does not impede finger joint motions.

NOTES

DISLOCATION AT THE SHOULDER JOINT

Anterior subcoracoid dislocation of the head of the humerus is the common type.

The patient supports the injured arm with the opposite hand, and the whole body tilts toward the affected shoulder There is flattening of the injured as compared to the normally rounded shoulder, and the head of the humerus, palpable anteriorly, moves with the shaft on rotation if fracture of the neck of the bone is not also present Satisfactory roentgenograms must be obtained to rule out a coincident fracture before any manipulation for reduction is undertaken Examination of the motor and the sensory nerves of the arm and hand is also essential before reduction is attempted in order that primary injury of nerves may be eliminated

Reduction —General anesthesia is advisable for reduction. Traction in the long axis of the arm, elbow flexed with pressure against the upper shaft of humerus from the axillary side, is successful in most cases Kocher's method of reduction is also used

First, the patient is placed on a flat table in a supine position The surgeon, grasping the flexed elbow with one hand and the wrist with the other, makes steady traction in the long axis of the shaft of the humerus

Second, with the patient's elbow pressed against the side of his chest during this traction, the arm and forearm are slowly rotated externally until the forearm is almost in the coronal plane of the body

Third, while the surgeon maintains traction and external rotation, the elbow is carried forward and inward, so that the olecranon approaches the xyphoid process

Fourth, holding the elbow in this position and using the forearm as a lever, the surgeon rotates the forearm and arm internally until the hand of the affected side rests on the opposite shoulder In case of fracture dislocation other methods using traction on the arm aided by pressure outward on the upper end of the humerus may be used These effect reduction and prevent a separated fragment of greater tuberosity or elsewhere from the head of the humerus from falling into the shoulder joint.

Immobilization —A Velpeau dressing or a sling and bandage are satisfactory for preventing recurrence of the dislocation Restriction of shoulder movements in the sling should be continued for five to six weeks During this period, however, the forearm may be

NOTES

exercised in extension under the personal supervision of the surgeon, without any active or passive abduction at the shoulder. Thereafter, physical therapy and active exercise may be undertaken gradually, and the arm may be carried in a sling part time. Active abduction is to be avoided for at least eight to ten weeks. "Pendulum" exercises are satisfactory methods for the restoration of abduction.

An unreduced old dislocation results in loss of function and often demands open reduction

NOTES

COMPRESSION FRACTURE OF THE SPINE

Fracture of the body of one or of several vertebrae may occur as the result of forcible acute flexion of the spine The force crushes and deforms the body of the involved vertebra The dorsolumbar region is most frequently affected. There may be transient or permanent damage to the spinal cord. In the majority of cases the spinal cord is not involved, the seriousness of the injury is not appreciated and unless a roentgenogram is made the fracture is overlooked and the patient treated for sprain of the back In most of these fractures the articular facets of the vertebrae remain face to face, but in a small group of less than 5 per cent the facets may override or be locked back to back, in which instances cord injury and symptoms are often found Roentgenograms of the spine in both the anteroposterior and lateral planes, therefore, are imperative

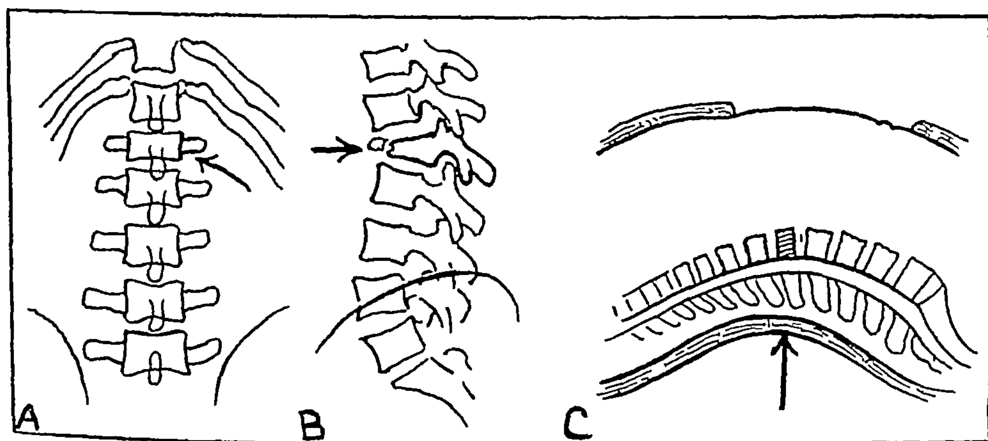


Fig 33 Compression fracture of the spine *A*, anteroposterior view, *B*, lateral view, *C*, position of the spine in hyperextension ready for immobilization

before proceeding with reduction by hyperextension. Failure to recognize and treat adequately a compression fracture of the spine may result in prolonged or even permanent disability

Reduction—Immediate reduction may be secured by hyperextension of the spine with the patient lying prone or supine (see Fig 34) Hyperextension aims to disimpact the fragments and to restore, so far as possible, the normal contour of the body of the vertebra Delayed reduction may be secured by placing the patient lying supine on a frame or bed which permits gradual hyperextension of the spine to be carried out

The roentgenograms of each patient must be studied to determine the exact relationship of the facets, because when they are

NOTES

back to back, or locked, hyperextension alone may lead to (damage or aggravate that already present. For these patients a tional manipulation, including traction in the long axis of spine, may be required to free the facets thus permitting subseq safe hyperextension and reduction.

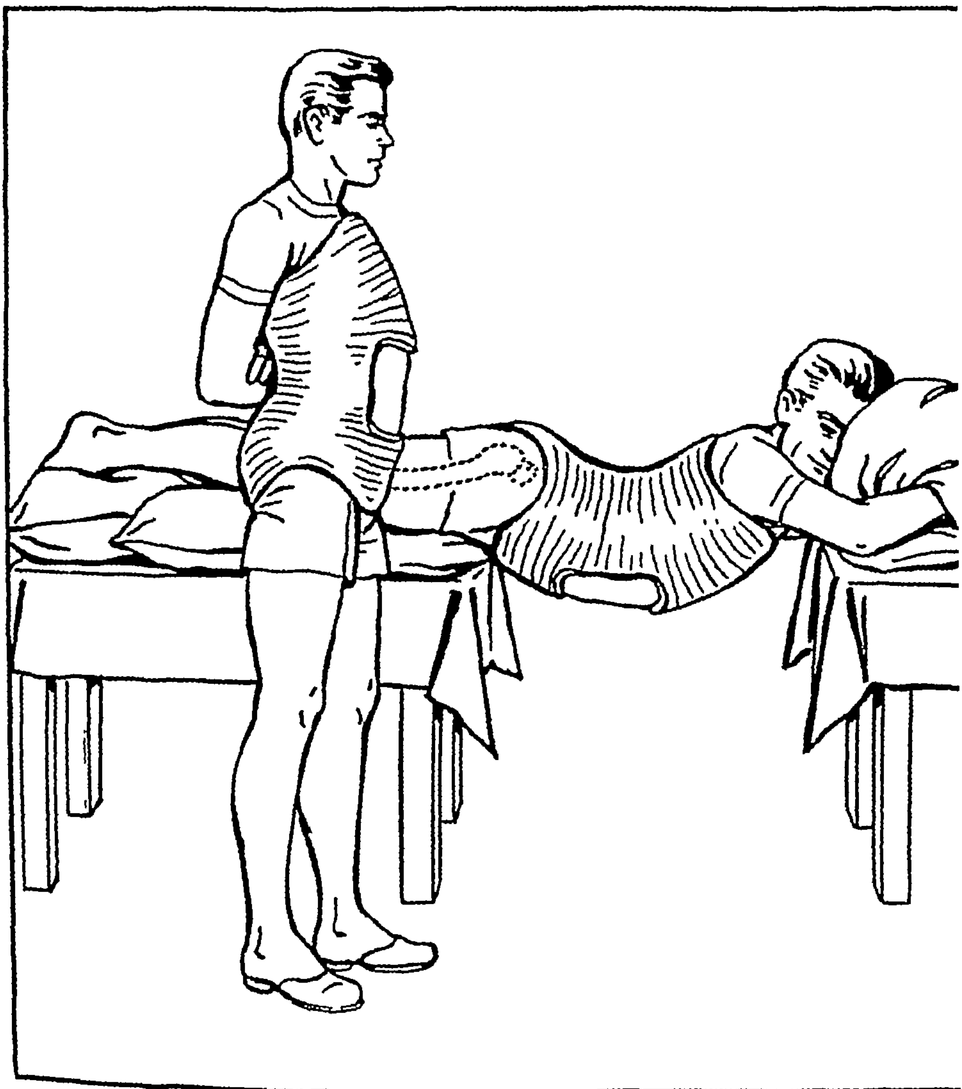


FIG 34 Plaster of paris jacket for immobilization, compression fracture of spine (Courtesy of *British Journal of Surgery*)

When a compression fracture is complicated by injury to cord, the seriousness of the condition makes consultation advisal

Immobilization—This may be secured by prolonged recu bency in hyperextension or by the application of a plaster of pa jacket extending from the episternal notch to the pubis, with spine in a position of maximal hyperextension at the site of fracture.

NOTES

After-Care.—When extension of the spine and immobilizati
are secured by recumbency in bed or frame, they must be mai
tained for eight weeks subject to control of restoration of the heig
of the compressed body as determined by lateral roentgenogram.
supporting plaster of paris jacket should then be applied in a po
tion of hyperextension and maximal reduction to be worn at lea
eight additional weeks.

When immobilization is secured by a plaster of paris jacket, a
plied after reduction as certified by roentgenogram, the patient m

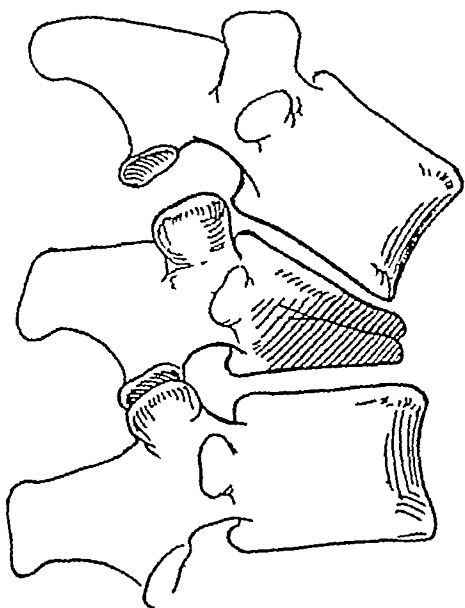


FIG 35. Wedge-shaped compression fracture of the spine

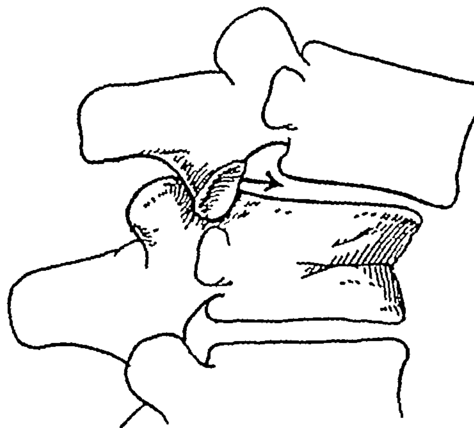


FIG. 36. Articular facets back to back in compression fracture of the spine.

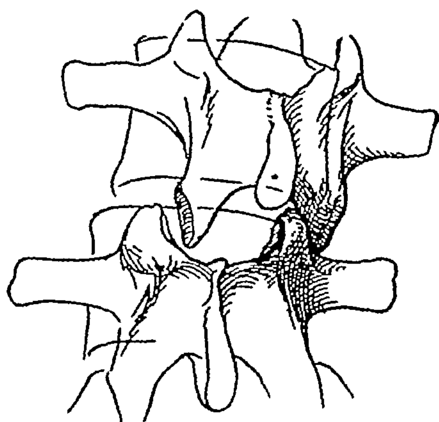


FIG 37 Facets overriding or locked in compression fracture of the spine

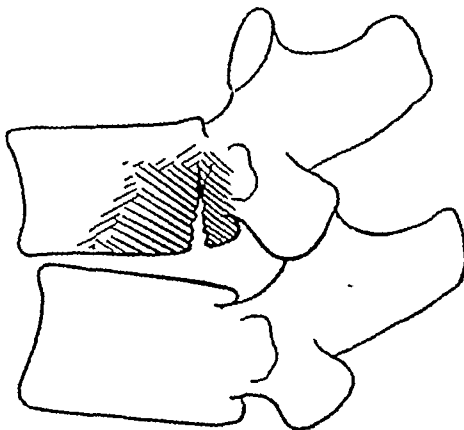


FIG 38. Fracture of the posterior margin of the centrum

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become ambulatory after from seven to ten days (see Fig. 34). The jacket should be worn at least sixteen weeks. Then a metal spinal brace maintaining hyperextension of the spine should be worn an additional nine months or until the roentgenogram shows rebuilding of the crushed vertebral body. Active hyperextension exercises to be practiced by the patient while in the plaster or the brace are distinctly advantageous in early muscular rehabilitation.

NOTES

COMPRESSION FRACTURE OF THE SPINE

Usually caused by sudden forced flexion. Immediate symptoms frequently slight.

If untreated, persistent delayed pain, postural deformity may develop.

Roentgenogram essential for diagnosis, lateral view absolutely essential.

SERIOUS GROUP . . . 95%+

Articular facets face to face. Wedge-shaped compression of body (see Fig. 35).

Cord symptoms usually absent.

Most patients have no paralysis.

Lateral roentgenogram necessary.

Use immediate hyperextension of spine to reduce and relieve distress.

After reduction, spine must be splinted in hyperextended position.

Later metal spinal brace needed. Treatment involves months of back support.

DANGEROUS GROUP . 5%−

Articular facets back to back (see Fig. 36).

Facets overriding or locked (see Fig. 37).

Fracture posterior margin of centrum (see Fig. 38).

Cord symptoms present or imminent.

Anteroposterior and lateral roentgenograms necessary.

Hyperextension of spine may damage cord.

Reduction only after study of displacement, usually first employing traction in long axis of spine.

After reduction treatment same as for serious group.

NOTES

COMPRESSION FRACTURES OF THE OS CALCIS

Fractures of the os calcis nearly always result from a fall from a height onto a hard surface They are frequently bilateral and accompanied by compression fracture of the bodies of the vertebrae These fractures unless properly reduced result in functional disability due to traumatic flat foot and interference with the lateral movements of the foot They are characterized by fragmentation and broadening out or mushrooming and tilting upward of the posterior part of the os calcis. The broadening of the bone frequently results in impingement against one or both malleoli at the ankle with pain resulting after weight bearing. The tilting upward of the posterior part results in loss of the tuber angle of the os calcis and the creation of a traumatic flat foot. Usually the fracture is comminuted and extends into the subastragalar joint which becomes painful with loss of abduction and adduction of the foot.

Roentgenograms of the heel should be made in two planes: a lateral view and a 45-degree angle exposure through the os calcis from behind and above to show the profile of the long axis of the bone.

Reduction.—Reduction is made by correcting the upward displacement of the posterior part of the os calcis, thus restoring the tuber angle. This may be accomplished by traction applied on a Steinmann pin transfixing the heel above the insertion of the tendo-achillis or through the posterior fragment of the bone, preceded by forcible lateral compression exerted by the surgeon's hands or better secured by forcible strokes from a padded mallet applied to the side of the heel with the foot resting on a sand bag (see Fig. 41) In some instances a second pin is put through the upper end of the tibia for countertraction.

Immobilization—After reduction and checking the position of fragments by roentgenogram, the foot is immobilized by a closely fitting molded plaster of paris dressing extending from the toes up onto the thigh with the leg flexed Hard felt half moon-shaped pads placed under the malleoli compressed firmly by the surgeon's hands as the plaster is applied may maintain the compression of the os calcis and free it from the malleoli. The heel after application of plaster should not be allowed to rest on table or bed until thoroughly hardened The traction pin should be left in place and incorporated into the plaster, while traction is maintained on it, to prevent upward displacement of the posterior part of the os calcis

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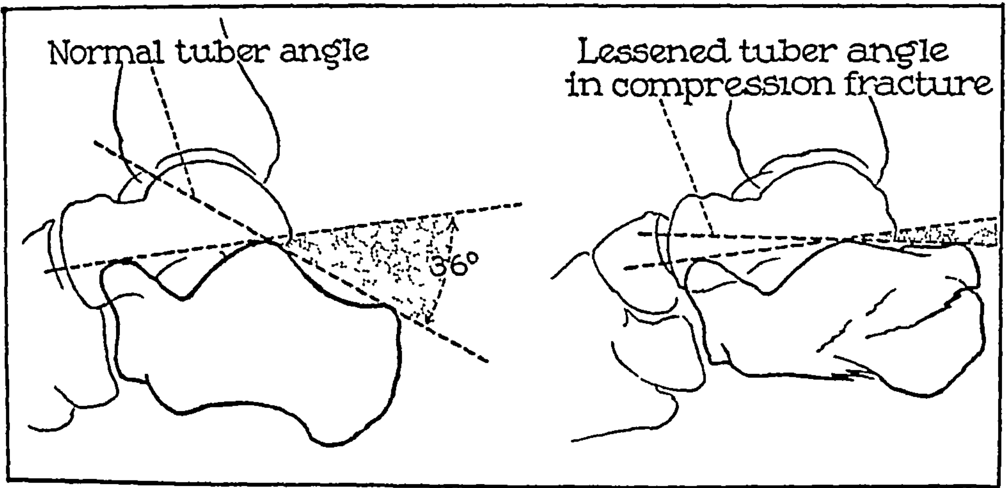


FIG. 39. Normal tuber angle at heel and lessened tuber angle after compression fracture of os calcis. Posterior fragment impacted and pushed upward.

Os calcis

Os calcis

Normal axis

Distorted axis after compression fracture

FIG 40 Postero oblique view of normal heel and os calcis compared with heel after compression fracture of the bone showing widening, impaction and axis distortion

NOTES

After-Treatment.—The plaster should be left on for at least twelve weeks without weight bearing. After that a weight-bearing cast with metal stirrup should be applied from toes up to the knee only. This is worn an additional four to six weeks. A properly supporting shoe is then applied and weight bearing gradually started.

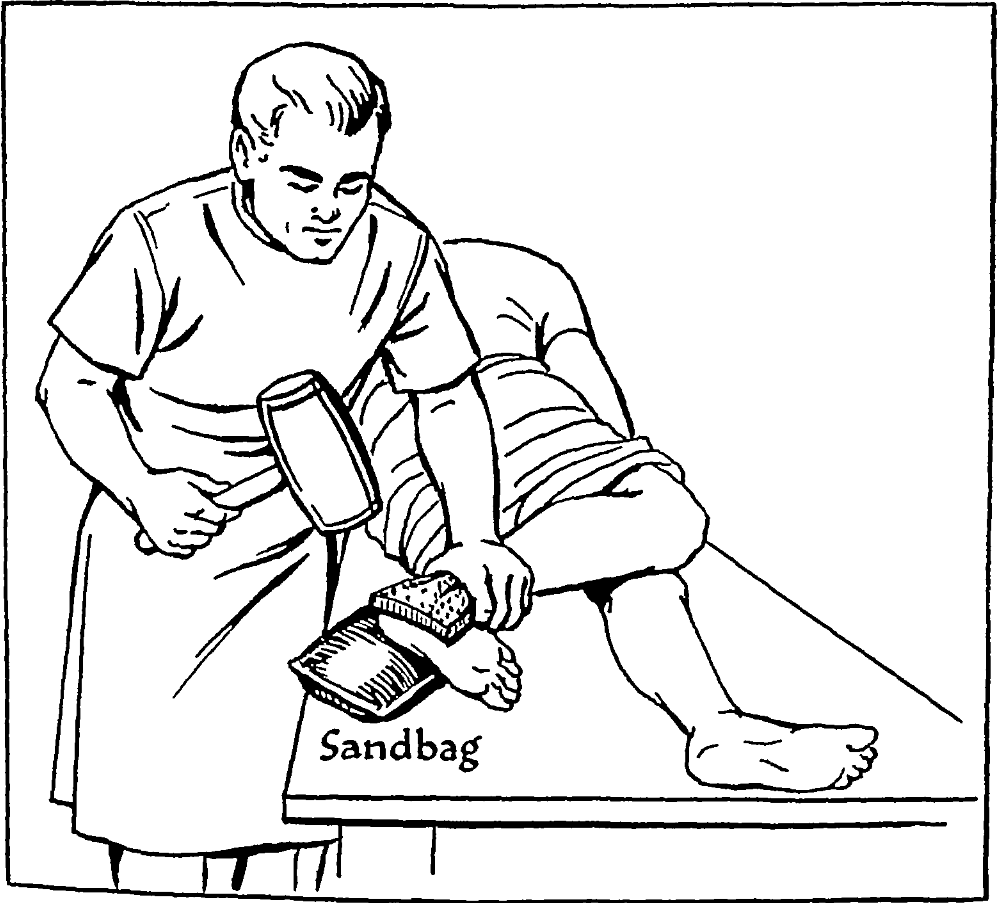


FIG 41 Correction of the broadening of the bone and of the changed salient angle are essential in reduction of compression fractures of the os calcis. This is done by forceful lateral compression with hands or with a padded mallet used with foot placed on its side on a sand bag, or by other instruments for compression The patient should be under anesthesia

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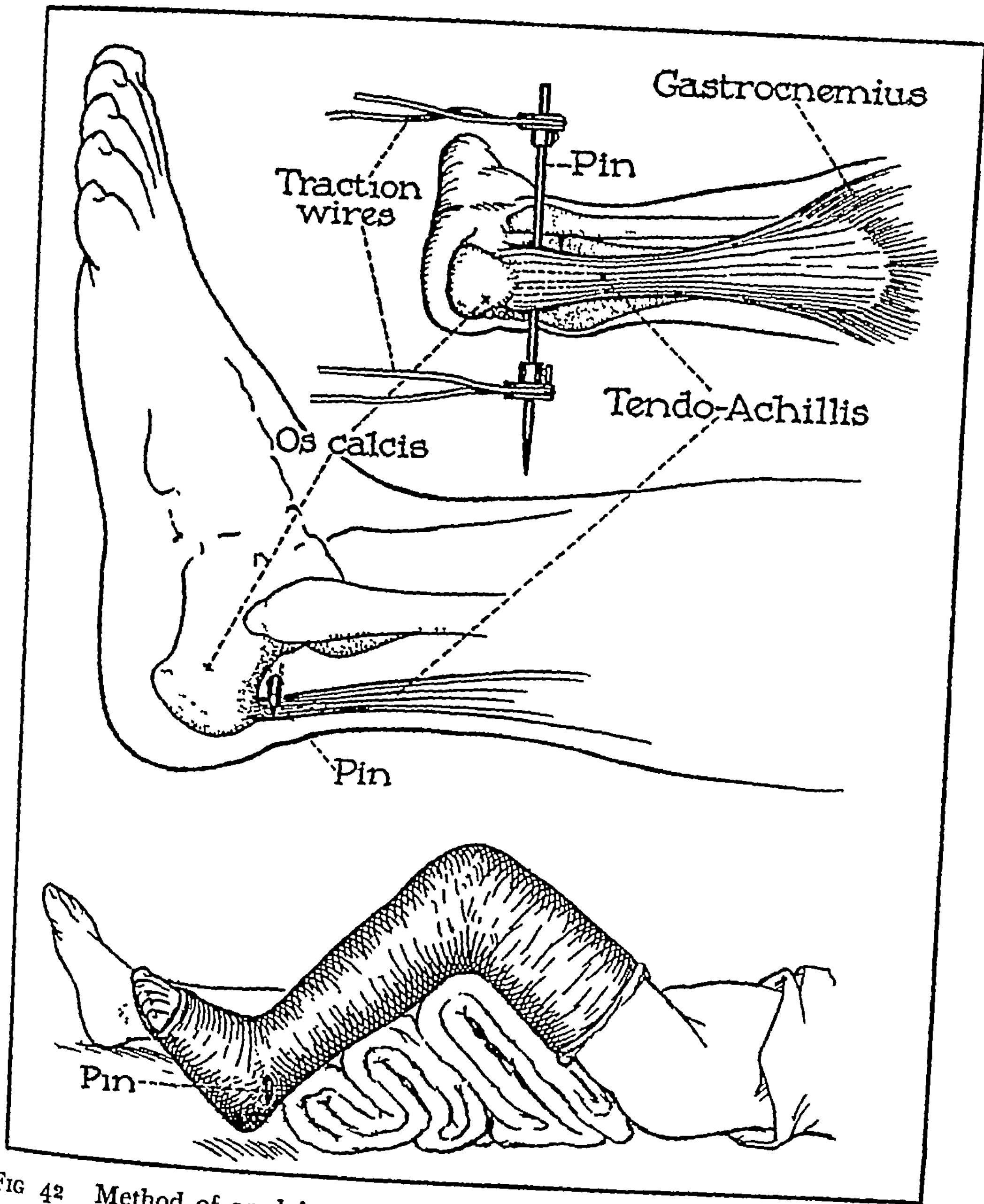


Fig 42 Method of applying traction to posterior fragment of os calcis after compression fracture The pin does not penetrate bone and is inserted after the broadening is corrected by hand compression or wooden mallet. (See Fig 41) After sustained correction, the pin is incorporated in plaster of paris dressing but the heel is not allowed to rest on bed until the plaster is thoroughly crystallized

NOTES

FRACTURE OF CARPUS, METACARPUS AND PHALANGES

FRACTURE OF CARPUS

Fracture of a carpal bone is often complicated by dislocation of the broken bone or its neighbors. The scaphoid is most often fractured and the semilunar most often dislocated. Diagnosis is impossible except by means of anteroposterior and lateral roentgenograms.

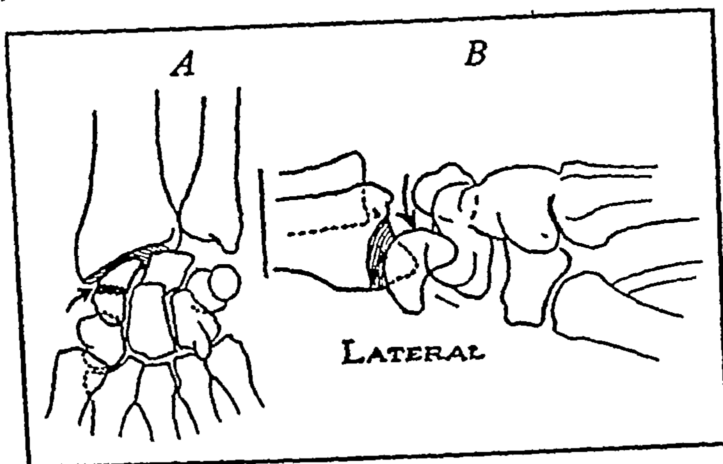


FIG 43 *A*, fracture of the carpal scaphoid; *B*, volar dislocation of the lunate.

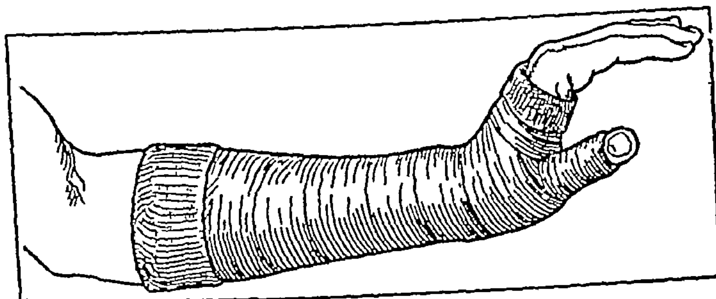


FIG. 44. Immobilization, fracture of the carpus.

Reduction and Immobilization—No reduction is necessary if the scaphoid is broken and the fragments are not displaced; the wrist and hand should be immobilized in a circular plaster which includes the thumb held in abduction and in slight dorsiflexion and radial deviation This must be worn for eight weeks.

After-Care—After the prescribed period of immobilization, the plaster is removed, carefully avoiding any movement of the wrist, and a roentgen examination will determine the presence or absence of bony union. If no union has been obtained, a similar plaster dressing must be applied for an additional eight weeks. When non-union, with pain or reduced function, persists operative treatment

NOTES

by drilling or bone transplant, followed by immobilization in plaster for three months, is required. This operation must be performed by a qualified surgeon.

Most of the other carpal fractures without displacement will heal promptly with immobilization by plaster splint in from four to six weeks. When dislocation or marked displacement of fragments occurs, closed reduction may occasionally be successful, but operative treatment is sometimes required.

FRACTURE OF A METACARPAL BONE

Fracture of a metacarpal bone arises from direct or indirect violence; in the first case it is accompanied at times by an open wound and may involve one or more bones. When such a wound is being debrided, the ends of the bones may be fitted exactly together.

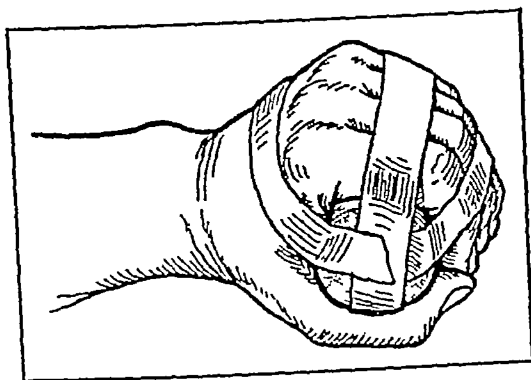


FIG 45 Roller bandage for immobilization, fracture of a metacarpal bone

Reduction—Reduction may be secured with the help of local or general anesthesia, manipulation, with traction and molding, is used. Continuous traction may be used to secure reduction; the traction should be applied to the finger attached to the fractured metacarpal bone. It is important to secure accurate alinement, as serious interference with the usefulness of the hand may result from malunion The position of the fracture should be checked by a roentgenogram after reduction

Immobilization—When reduction has been secured by manipulation, a plaster dressing may be used to immobilize the fracture or the hand may be bound securely to a roller bandage with the fingers in a position of partial flexion

After-Care—Immobilization should be maintained for four weeks and heavy use of the hand avoided for two weeks more. Muscular pull may cause angular deformity at the site of the fracture

NOTES

FRACTURE OF A PHALANX

Fracture of a phalanx is sometimes accompanied by an open wound. It may involve the shaft of the bone or occur at the extremity of the bone and involve a joint. The displacement of fragments in an oblique or a spiral fracture is often stubbornly difficult to reduce.

Reduction.—Reduction may be secured by traction, molding and manipulation of the phalanx. Continuous traction may be used to secure reduction.

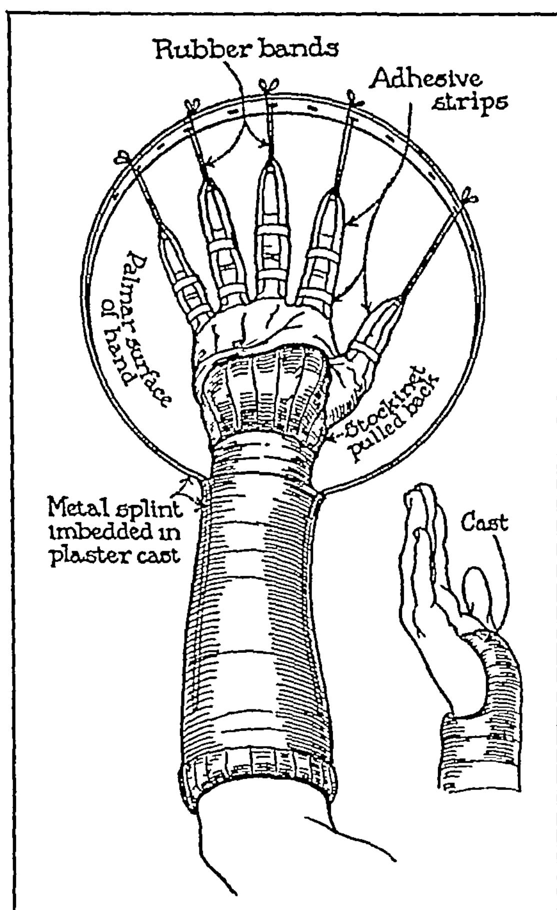


FIG 46 Immobilization, fracture of a phalanx, banjo splint. The fingers may be flexed while in traction to conform to the physiologic position of the relaxed hand.

Immobilization.—Immobilization may be efficiently maintained by use of a palmar molded curved or ball splint, a flexible metal splint or by traction Traction should be used if the fracture involves the end of the phalanx and enters a joint, as this form of immobilization lessens the danger of interference with articular function

NOTES

After-Care.—The fracture should be immobilized for three weeks, heavy use should be avoided for two weeks longer. Especial attention must be given to fracture of the thumb, to preserve the mobility of this most important finger.

NOTES

ACTIVE MOVEMENT IN THE TREATMENT OF FRACTURES

The most valuable treatment after a fracture has been reduced and properly healed is active motion performed by the patient himself. Passive movements may be distinctly harmful and should be performed only by the physician himself They produce reactions indicated by pain, swelling and increased stiffness about the

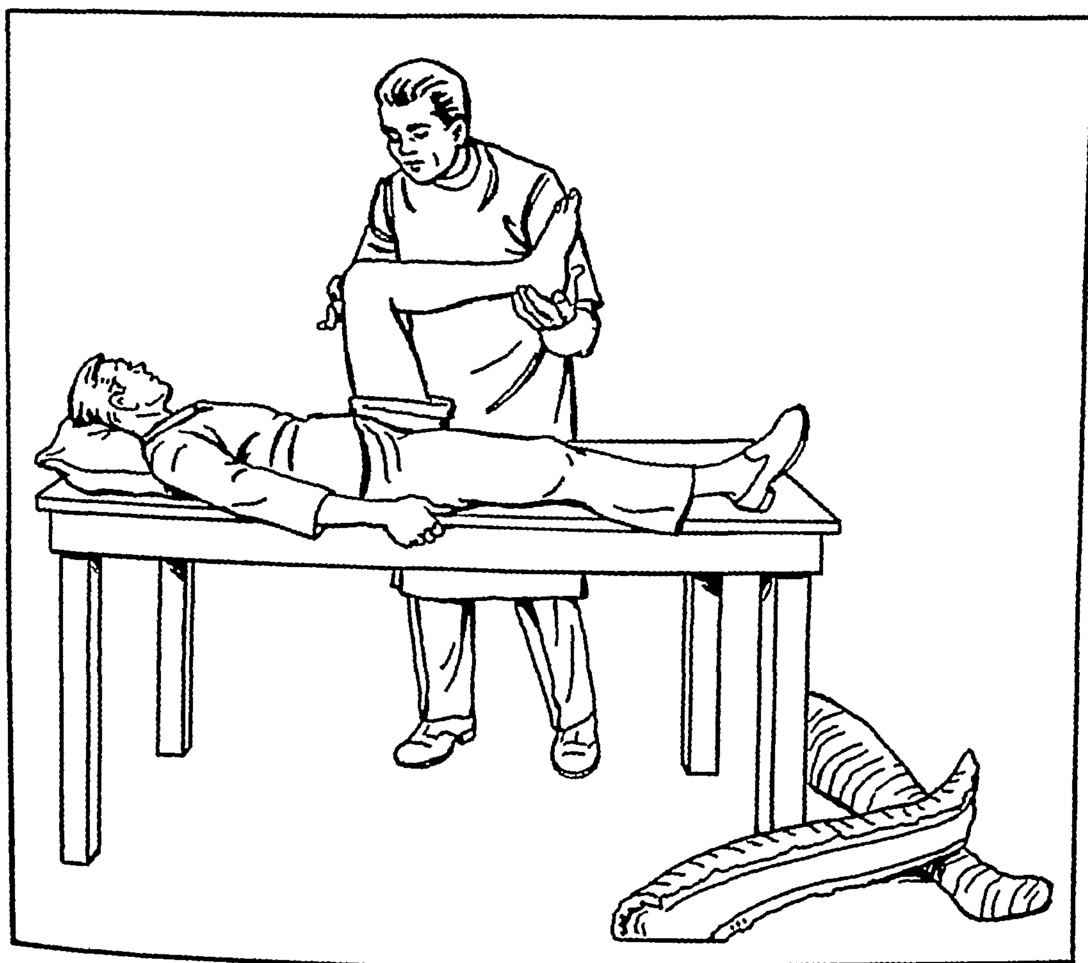


Fig 47 Active movement in the treatment of fractures

joints They lead to fresh plastic effusions and result in excessive formation of callus When a joint is involved by the fracture, the joint may easily be made permanently stiff by continued attempts to reestablish motion passively Painful passive movements mean tearing of tissue and more hemorrhage and scar tissue. The elbow joint is perhaps the one most frequently harmed by passive movements It is the custom of the uninformed to try to "pump handle" motion back into it. If this is persisted in, the result is a stiff elbow.

NOTES

Active movements, however, should be encouraged as soon as possible after the reduction of a fracture. The patient should be taught to "set" his muscles early in the course of healing of any fracture. This is especially important in fracture of the thigh or leg. The quadriceps femoris group of muscles atrophies quickly and power is lost from nonuse. Patients who have their lower extremities encased in plaster or in extension appliances should be taught to "set" the quadriceps group many times a day. Active movements of the muscles are of great value in lessening the period of disability and in securing early functional return. At the start the patient will often require guiding by the physician, who supports the part and encourages the patient, as shown in the diagram.

NOTES

NOTES

SPLINTS AND THE ACCESSORIES FOR THE DOCTOR'S AUTOMOBILE

1 Thomas leg splint, half ring

½ dozen bass wood splints (2½ inches wide). Enough sheet wadding or cotton (padding).

1 tourniquet

1 muslin arm sling.

1 can of ether (½ pound size)

6 bandages (muslin, 2 inches and 3 inches wide).

1 small roll of adhesive tape.

1 package of safety pins

SPLINTS AND THE ACCESSORIES FOR THE DOCTOR'S OFFICE

2 Thomas leg splints

1 dozen splint boards of bass wood ⅛ by 3 by 24 inches

2 dozen plaster of paris bandages wrapped in paper napkins, kept in an air-tight tin box in a dry place

2 dozen sheet wadding rolls 4 inches wide, 5 yards long, or nonabsorbent cotton

1 yard of saddler's felt, ½ inch thick.

3 rolls of zinc oxide adhesive plaster 5 yards long and 2 inches wide.

6 sand bags made of heavy canvas, 9 by 1 or 2 inches wide Rubber tubing, ½ inch, several long pieces for a tourniquet

2 dozen webbing straps and buckles, 2 feet long.

2 dozen 1- to 3-inch muslin roller bandages.

MISCELLANEOUS

Screw eyes, pulleys, cord rope, weights or bags for sand, screw driver, saw, wire pliers, monkey wrench, gimlet and hammer

INDEX